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AMERICAN ARCTIC AND RELATED CEPHALOPODS

AUG. F. FOERSTE

Received October 21, 1927; published January 20, 1928

Arctic America is an immense area approximately triangular in form. Its southern margin rests on the American continent and its apex projects northeast into Polar areas. In an east and west direction, from the southern end of Greenland to the west margin of Banks Island, the extent of Arctic America equals that from the Atlantic to the Pacific between northern Florida and southern California. The northeastward extension of Arctic America equals the distance from the Gulf of Mexico to Hudson Bay.

Of the geology of this area we know relatively little. Although the numerous voyages into this area have added greatly to our knowledge of its geography, our knowledge of its geology remains very fragmentary and disconnected. Few of those who have accompanied Arctic expeditions have had adequate training in geological methods of research, and among these only two are noteworthy for the detailed stratigraphic results which they brought back.

The first trained geologist to visit Arctic America was Per Schei, who accompanied the second Norwegian Arctic Expedition of the "Fram" in 1898–1902. During the autumn of 1898 and the spring of 1899 he visited that part of eastern Ellesmereland which lies west of the Kane Basin, and during the years 1900–1902 he investigated the southwestern part of Ellesmereland, especially that part bordering on Goose Fjord. His collections have given rise to a notable series of reports by Kiaer, Nathorst, Meyer, Loewe, Holtedahl, Tolmachoff, and others, which have added greatly to our knowledge of the sequence of strata there exposed.

The second geologist to visit Arctic America was the Danish geologist and explorer Lauge Koch. During the Second Thule

Expedition he surveyed Melville Bay and part of the northern coast of Greenland. During the years 1920–1923 he finished mapping the northwestern and northern coasts of Greenland and in addition made such large and intelligent collections of the fossils exposed on the eastern margin of the Kane Basin and the adjacent part of Kennedy Channel that this has become the best known part, geologically, of the entire American Arctic. Recently he has returned from a third expedition, visiting the northern half of eastern Greenland, in the area extending from Scoresby Sound to Denmark Harbour, bringing home 8 tons of fossils, from numerous horizons, extending from as low as the Lower Cambrian to the Eocene. It will readily be recognized how much more can be learned from a series of collections made in stratigraphic sequence than from miscellaneous gatherings made by collectors to whom the significance of collecting from definite horizons had little meaning.

The first fruits of the collecting by Lauge Koch have appeared recently in two memoirs, published as part of a series entitled Jubilaeumsekspeditionen Nord Om Grønland, 1920–1923, in the Saertryk af Meddelelser om Grønland. No. 2 of this series, published in 1927, includes a study of the Cambrian, Ozarkian and Canadian Faunas of that part of northwest Greenland which borders on Kane Basin, by Christian Poulsen. No. 1 of this series includes a study of the cephalopods of the Black River, Trenton and Richmond formations by Gustaf T. Troedsson, published in 1926. Both of these reports form notable additions to our knowledge of Arctic Paleozoic faunas, representing a standard of work which it is hoped will inspire others to similar efforts. As a result of these studies it has been possible to discriminate the following horizons in the Kane Basin area:

Horizons	*Greenland Formation Names*
Richmond, Trenton, Black River (Watertown)	Cape Calhoun
Black River (Lowville)	Gonioceras Bay
Upper Canadian	Nunatami
Upper Ozarkian	Cape Clay, Cass Fjord

Horizon	*Greenland Formation Names*
Lower Ozarkian	Cape Frederick VII Pemmican River
Middle Cambrian	Cape Wood
Lower Cambrian	Cape Kent Wulff River

In a letter to the writer, Lauge Koch stated that during the whole time he was in Greenland he had a suspicion that the Cape Calhoun series included various zones. But the Bluffs where the exposures occur are absolutely vertical, and, since they consist of quite homogeneous limestone, it was not possible to distinguish the zones while collecting from the talus at the base of the bluffs. Professor Troedsson has attempted to discriminate in the Cape Calhoun series three zones, respectively of Black River (Watertown), Trenton, and Richmond age. How successful he was in this attempt cannot be determined until other exposures are found where collecting can be done from these zones separately.

These Cambrian, Ozarkian, Canadian, and Ordovician strata dip gently toward the north-northwest along the eastern side of Kane Basin, the Cape Calhoun series forming the cliffs at the extreme northern edge of the basin. North of Cape Calhoun, this Cape Calhoun series is overlaid unconformably by beds containing graptolites, determined by Christian Poulsen as of Lower Birkhill age, which are equivalent approximately to the Lower Clinton of the more southern areas of the North American continent. The following graptolites are listed by Troedsson from this horizon: *Climacograptus scalaris* (His.), *Rastrites peregrinus* Barr. var. *socialis* Törnq., *Monograptus lobiferus* M'Coy, and *Monograptus convolutus* (His.).

Silurian strata form the exposures along the eastern side of Kennedy Channel from Cape Calhoun northward to Bessels Bay and Peterman Fjord. In Bessels Bay was found the specimen here identified as *Armenoceras* cf. *rotulatum* (Billings). The type of this species was found in the Lake Timiskaming area at a Silurian horizon approximately equivalent to the Manistique of northern Michigan. From Offley Island, at the mouth of Petermann Fjord, Foord described and figured the two Silurian specimens here identified as *Kionoceras* cf. *myrice* (Hall and Whitfield) and *Monocyrtoceras arcticum* (Foord). These suggest an horizon

approximately equivalent to the Racine of southeastern Wisconsin and northern Illinois. Dr. Poulsen at present is engaged on the study of the Silurian Fossils brought back by Lauge Koch, and we eagerly await the results of his studies.

The various Cambrian, Ozarkian, Canadian, Ordovician, and Silurian strata exposed along the eastern short of Kane Basin and Kennedy Channel appear to extend in a direction north of east, across the northern part of Greenland, to Independence Fjord, on its eastern coast. This is indicated by Lauge Koch on the map published by him as fig. 3 in his article on "The Geology of North Greenland," in the American Journal of Science, vol. 9, 277 (1925). Some of the horizons in eastern Greenland have furnished fossils for identification. In a letter written by Lauge Koch since his return from his last expedition to East Greenland, he states that during the latter part of the Algonkian a thick series of strata was deposited in East Greenland, just as in North Greenland. These consist of red sandstone, conglomerates, and dark limestone, overlain by two disconformities. At the base of a series of limestones from 300 to 600 meters thick, a Lower Cambrian *Olenellus* fauna was found, but this fauna has not been sufficiently studied to determine its paleogeographic relationship. Then follows an Upper Ozarkian fauna very similar to the Cass Fjord formation on the eastern side of the Kane Basin. This Upper Ozarkian fauna contains very well preserved trilobites. Still higher occurs a badly preserved cephalopod fauna of Arctic Black River age. Here, also, it will be necessary to await future studies in order to learn the full significance of these studies.

The series of strata exposed along the eastern margin of Kane Basin and Kennedy Channel is to be expected also along their western margin, though faulting confines their exposure only to the immediate vicinity of these waters, as shown by fig. 2 of Lauge Koch's article on The Geology of North Greenland, cited above. Our knowledge of the lower strata along the western margin of the Kane Basin we owe to Per Schei, whose collections were studied by Olaf Holtedahl.[1] From Cape Camperdown, at the south-

[1] Olaf Holtedahl. The Cambro-Ordovician Beds of Bache Peninsula and the Neighbouring Regions of Ellesmere Land. No. 28 of Report of the Second Norwegian Expedition of the "Fram," in 1898–1902.

eastern corner of the Bache Peninsula he identified some trilobite remains as belonging to the genus *Ptychoparia*, suggesting a Middle or Upper Cambrian horizon.

The next higher horizon consists of light greyish-white limestone, about 350 feet thick, which crops out midway up the vertical face of Cape Victoria Head. This is the *Orthoceras* limestone of Per Schei. From fragments kindly loaned by Dr. Holtedahl the present writer described *Clarkoceras holtedahli* and *Ellesmereoceras scheii*.[2] At the time these species were described the genotype of *Clarkoceras*, namely *Clarkoceras newtonwinchelli*, was still regarded as of Shakopee, or Upper Canadian age. At present it is definitely known that both genera, *Clarkoceras* and *Ellesmereoceras*, are confined to the Upper Ozarkian, so that this establishes also the Upper Ozarkian age of that part of the *Orthoceras* limestone from which Per Scheii obtained the two species named above.

It is possible that the Canadian is represented in the upper part of the exposures at Victoria Head. Of the presence of the Cape Calhoun series, however, there is no doubt. The locality at which Per Schei collected his fossils was in Norman Lockyer Island, directly north of Victoria Head, at the northern edge of the mouth of Princess Marie Bay. Here several fragments, one of them from 110 to 120 mm. in width, were identified by Holtedahl as *Gonioceras occidentale* Hall. In general, this Norman Lockyer Island fauna suggests a Black River horizon, though some of its members, such as *Halysites* and *Calapoecia*, are known also from the Richmond. Additional outcrops of strata belonging to the Cape Calhoun series are indicated by the occurrence of *Kochoceras feildeni* at Cape Louis Napoleon, and of *Kochoceras lenticulare* from some unknown point probably between Dobbin Bay and Scoresby Bay. Both of these species were found on the western side of Kane Basin, directly southwest of Cape Calhoun. Judging from the horizon assigned by Troedsson to most species of *Kochoceras* found in the Cape Calhoun series, these species

[2] A. F. Foerste. Notes on Arctic Ordovician and Silurian Cephalopods, chiefly from Boothia Felix—King William Land, Bache Peninsula, and Bear Island; Jour. Sci. Labs. of Denison Univ., 19, 261, 265; pls. 27, 33 (1921).

suggest the presence of the upper, or Richmond part of this series also on the western side of the Kane Basin.

The presence of the specimen here identified as *Armenoceras sphaeroidale* in some part of Dobbin Bay suggests the presence here also of some member of the Silurian, corresponding approximately to the Manistique of Drummond Island, in northern Michigan. This, however, needs confirmation in view of the fact that *Nybyoceras bekkeri* Troedsson, from the Lyckholm beds at Nyby, Esthonia, would present a similar cross-section, and relatively little is known of the structure of the Dobbin Bay specimen here referred to *Armenoceras sphaeroidale*.

The most striking feature of the Cape Calhoun fauna is its great resemblance to that fauna in southern Manitoba which for many years was regarded as of Black River age, but which more recently has been assigned to the Richmond, being regarded as an Arctic phase of the latter. In southern Manitoba, most of the cephalopods known from these strata come from their lower, or Winnipeg division, only one species, *Apsidoceras insigne* Whiteaves, being known from its upper, or Stony Mountain division.[3]

In the area west of Hudson Bay, the Cape Calhoun series is represented by the Nelson and Shamattawa limestones, the former corresponding approximately to the Winnipeg formation in southern Manitoba, and the latter to the Stony Mountain formation of that area.

The Cape Calhoun series appears to be represented also on Igloolik Island, half-way between Cape Calhoun and the exposures on the Nelson and Shamattawa rivers west of Hudson Bay. This is suggested by the presence of *Kochoceras mantelli* and *Kochoceras foordi*, described on the following pages. This is also the locality from which *Armenoceras lyoni* was described by Stokes, a species closely related to *Armenoceras richardsoni*, a characteristic fossil from the Lake Winnipeg area in southern Manitoba.

Incidentally, the occurrence of a species of *Kochoceras* in the Great Slave Lake area in northwestern North America also should

[3] Aug. F. Foerste and T. E. Savage. Ordovician and Silurian Cephalopods of the Hudson Bay Area. Jour. Sci. Labs. of Denison Univ., 22, pp. 7, 8 (1927).

be noted. This species was figured by Foord,[4] in his Catalogue of Fossil Cephalopoda under the generic term *Actinoceras*.

Another fauna which appears to have relationship with the Cape Calhoun fauna is that so well described by Schuchert[5] from Silliman Fossil Mount, at the head of Frobisher Bay in the southeastern part of Baffin Island. There appears to be here an intermixture of Trenton and Richmond fossils. The present writer, however, is unable to determine which of the cephalopods described from this area are to be considered as of Trenton, and which as of Richmond age. It may be noted, however, that the species described here as *Charactoceras schucherti* finds a near relative not only in *Charactoceras plicatus* (Whiteaves) from the Winnipeg limestone in the southern part of Manitoba, but also in *Charactoceras rotundum* Troedsson from the Richmond part of the Cape Calhoun series. Moreover, the specimens from Frobisher Bay which were listed by Schuchert under *Cyrtoceras manitobense* appear identical with those described by Troedsson from the Richmond part of the Cape Calhoun series under the name *Thuleoceras ornatum*. None of the other cephalopods described by Schuchert appear to have Richmond rather than Trenton affinities.

Such species as *Calapoecia canadensis* and *Halysites gracilis* suggest Richmond or Black River rather than Trenton relationships. It is hoped that the researches made by Sharat K. Roy last summer, in the Frobisher Bay area (Science, p. 473, 1927) will clear up this question of stratigraphy, long in doubt.

The fauna enclosed in the erratic blocks found at Port Burwell, west of Cape Chidley, at the northern end of Labrador, are regarded as of Black River age. In a similar way, the miscellaneous fauna brought back by Amundsen from unknown localities either in the eastern half of King William Land or from some part of western Boothia also is regarded as of Black River age. The specimen formerly identified by the writer from this area as either

[4] A. H. Foord. Catalogue of the Fossil Cephalopoda in the British Museum, pt. 1, p. 165, figs. 23, 22–2 (1888).

[5] Charles Schuchert. On the Lower Silurian (Trenton) Fauna of Baffin Land. Proc. U. S. National Museum, 22, pp. 143–177, pls. 12–14 (1900).

a *Cyclendoceras* or a *Dawsonoceras* probably is neither,[6] but apparently is a *Spyroceras*, of Ordovician age. *Dawsonoceras* is unknown on the North American continent in strata of earlier than Silurian age. At the time this Boothia Felix-King William Land fauna was being studied by the present writer, he did not know any forms of *Spyroceras* which were likely to have an appearance similar to *Dawsonoceras* when deprived of their shell. However, in more recent years, he found an undescribed species among specimens collected from the English Head and Vaurial formations of Anticosti, which have an aspect closely similar to that of *Dawsonoceras* (?) *aquilonare* Troedsson from the Richmond part of the Cape Calhoun series, when deprived of their shell. In this species, for which the name *Spyroceras microlineatum* is proposed, the inner layers of the shell are ornamented by numerous vertical raised lines, about 11 in a width of 1 mm. It is assumed that the outer layers of the shell were similarly striated. The type specimen is from Cape Henry, in zone 3 of the Vaurial formation, and is numbered 3835 in the collections at Yale University.

It is evident that our progress in paleogeography is very much impeded by our present very inadequate knowledge of the geology of Arctic Lands. On that account the recent contributions by Troedsson and Poulsen are highly welcome. It is especially desired to know which Arctic faunas are American in their affinities, which are European, and which are common to both.

According to Poulsen,[7] the Wulff River fauna represents an incursion of the Atlantic ocean during Lower Cambrian times. The Cape Kent, Cape Wood, and Pemmican River faunas, on the contrary, show affinities with those of the Cordilleran areas of western North America. Of these three, the Cape Kent fauna is most comparable with the Lower Cambrian fauna of the Mount Whyte formation in British Columbia, Alberta, and the western

[6] Aug. F. Foerste. Notes on Arctic Ordovician and Silurian Cephalopods, Jour. Sci. Labs. of Denison Univ., 19, p. 301, pl. 31, fig. 2 (1921).

[7] Christian Poulsen. The Cambrian, Ozarkian, and Canadian Faunas of Northwest Greenland. Saertryk af Meddelelser om Grønland, 70, No. 2 of Jubilaeumsekspeditionen Nord om Grønland, in 1920–1923 (1927).

part of the United States. The Cape Wood fauna is most comparable with the Middle Cambrian fauna of the Stephan formation of British America and Alberta. As regards the Pemmican River formation, the single species of trilobite identified so far is very closely related to a species found in Montana in strata whose age is not definitely known, beyond the fact that it is either Upper Cambrian or Lower Ozarkian. The Cape Frederick VII and Cass Fjord faunas can not be correlated at present with faunas known elsewhere. In the case of the Cape Frederick VII fauna, the identified trilobite material is altogether new, even generically. However, the Cape Clay fauna is distinctly related to the Upper Ozarkian of the Mississippi Basin, including the Oneota of Wisconsin, Minnesota, and Iowa; the Gasconade of Missouri and Arkansas; and the Chepultepec of Tennessee and Alabama. According to Poulsen it has affinities also with certain Ozarkian strata in Pennsylvania and eastern New York. In a similar manner, the Nunatami fauna presents relationship with the Upper Canadian faunas of Missouri and Arkansas, in the Mississippi Basin, and also with the Upper Canadian faunas of Vermont and of the Phillipsburg area in southern Ontario.

Troedsson[8] discriminated two Black River horizons among the strata immediately overlying the Canadian. The lower of these, tentatively correlated with the Lowville, he called the Gonioceras Bay formation. The upper horizon, tentatively correlated with the Watertown member of the Black River, he detected among the material collected in the Cape Calhoun series. . In a similar manner he discriminated among the fossils collected from the Cape Calhoun series those which he regarded as of Galena-Trenton age. However, he states that "There is no doubt that the main part of the Cape Calhoun fauna belongs to the Richmond." In general, the relationship of the Black River faunas of the Kane Basin is with that of the eastern half of the United States, extending from New York to Wisconsin and Minnesota, and thence southward into Kentucky and Tennessee. The Rich-

[8] Gustaf T. Troedsson. On the Middle and Upper Ordovician Faunas of Northern Greenland. Pt. 1, Cephalopods. No. 1 of Jubilaeumsekspeditionen series, mentioned in previous reference. (1926).

mond of the Kane Basin, on the contrary, is not the typical Richmond of the Ohio valley, nor the Richmond of the upper Mississippi valley, but the Richmond of southern Manitoba. It is this Manitoba type of Richmond which extends far southward through Montana, Idaho, and Colorado, toward Texas.

It has already been stated that Dr. Poulsen[9] regards the lowest Silurian exposed north of Cape Calhoun to be of Lower Birkhill age, and hence to represent an Atlantic invasion. The few Niagaran fossils studied by the present writer from the northern end of the Kennedy Channel suggest affinity with the Niagaran of southeastern Wisconsin, chiefly with its Racine member. Additional information will, no doubt, be supplied by Dr. Poulsen, as a result of his studies on material brought back by Dr. Lauge Koch.

A still higher horizon is that frequently referred to in Arctic geological literature as the *Lissotrypa phoca* horizon. According to Holtedahl,[10] the *Lissotrypa phoca* fauna "is known from a large area, from the Kennedy Channel districts in N. E. (Dobbin Bay, Bessel Bay), across North Devon (Beechey Island fauna) to Cornwallis Island, Griffith Island, North Somerset, and Cape Farrand (East side of Boothia) in S. W." This is a typical American Arctic fauna. Holtedahl, who has given this fauna special attention, places it at the top of the Silurian, recognizing, however, its pronounced Lower Devonian affinities. Schuchert, on the contrary, influenced by these Lower Devonian affinities, refers this *Lissotrypa phoca* fauna to the Lower Devonian.[11]

On Cornwallis Island this *Lissotrypa phoca* fauna contains unidentifiable specimens of *Orthoceras*, *Sactoceras*, and *Ormoceras*, associated with *Armenoceras donnetti*, and *Armenoceras ommaneyi*. Salter described from this island also a nautiloid under the

[9] Christian Poulsen in Troedsson. On the Middle and Upper Ordovician Faunas of Northern Greenland, 113, 115 (1926).

[10] Olaf Holtedahl. On the Rock Formations of Novaya Zemblya with Notes on the Paleozoic Stratigraphy of other Arctic Lands. No. 22 of the Report of the Scientific Results of the Norwegian Expedition to Novaya Zemblya, in 1921, 128–132 (1924).

[11] Charles Schuchert. Notes on Arctic Paleozoic Fossils. Amer. Jour. Sci., 38, 467–477 (1914).

generic name *Lituites*, comparing it, however, with the Silurian species now known as *Ophidioceras extricatum* (Sowerby). From Griffith Island, *Orthoceras griffithi* was described.

In a recent letter by Lauge Koch, he refers to the presence in eastern Greenland of almost unfossiliferous Old Red Sandstone or Upper Devonian, but mentions wood and plant remains. This is overlaid by fresh water deposits containing mollusks and fish remains. Then follow conglomerates overlain by white limestone containing a rich Lower Carboniferous marine fauna (absolutely unknown in Scandinavia and Spitzbergen). Middle Carboniferous is represented by sandstone containing *Lepidodendron*. Then follows the Upper Carboniferous and the Permo-Carboniferous *Productus* fauna which is known from Arctic North America also in Grant Land, and which occurs also in Spitzbergen and North Russia.

The present paper is presented in the effort to add a little to our knowledge of American Arctic Ordovician and Silurian cephalopods. Most of it consists of a restudy of material already published, but a part is based on material hitherto not subjected to close study. This material was secured from various sources.

Dr. F. A. Bather, keeper of the Geological Department of the British Museum, loaned for study some of the unpublished material collected by various British exploring expeditions at various localities in the American Arctic. He also forwarded casts of types of some of the Arctic cephalopods desired for comparison, and supplied notes supplementing the information given by these casts. Dr. E. M. Kindle loaned those specimens in the Victoria Memorial Museum which had been collected by Dr. A. P. Low at Port Burwell, west of Cape Chidley, at the northern end of Labrador, and also furnished information regarding the distribution of the *Manticoceras intumescens* fauna in Canadian areas. Dr. R. S. Bassler permitted access to the Frobisher Bay specimens, and provided facilities for study at the U. S. National Museum. Prof. Thomas H. Clark loaned those specimens of *Dawsonoceras* which were preserved in the Redpath Museum at McGill University, here discussed. Dr. Chester A. Reeds loaned the specimens of *Plectoceras* and *Eurystomites* from the Hall collection, here re-

studied. Prof. W. H. Shideler loaned some specimens of the species originally described as *Orthoceras turbidum*, for comparison with the species described by Troedsson under the names *Sactoceras striatum* and *Sactoceras lineatum*, from the Richmond part of the Cape Calhoun series in northwestern Greenland.

It is these contributors who have made possible the paper here presented, and to all of these the writer here expresses his sincere thanks and his deep appreciation of the favors conferred.

LIST OF SPECIES DESCRIBED

1. Endoceras chidleyense Foerste
2. Endoceras baffinense Foerste
3. Cyclendoceras boreale Foerste
4. Cyclendoceras (Mount Beaufort)
5. Orthoceras griffithi Haughton
6. Orthoceras cf. griffithi Haughton
7. Orthoceras (?) sp. (Cornwallis Island)
8. Ephippiorthoceras compressum Foerste
9. Ephippiorthoceras baffinense Foerste
10. Sactoceras (?) sp. (Griffith Island)
11. Sactoceras (?) sp. (Griffith and Cornwallis Islands)
12. Dawsonoceras hyatti Foerste
13. Dawsonoceras granti Foerste
14. Dawsonoceras annulatum (Sowerby)

14a. Dawsonoceras americanum (Foord)

15. Spyroceras baffinense (Schuchert)
16. Spyroceras porteri (Schuchert)
17. Kionoceras cf. myrice (Hall and Whitfield)
18. Kionoceras scalariforme (Schuchert)
19. Troedssonoceras turbidum (Hall and Whitfield)
20. Beloitoceras arcticum (Schuchert)
21. Beloitoceras (?) cornulum (Schuchert)
22. Beloitoceras (?) baffinense (Schuchert)
23. Plectoceras undatum (Conrad)
24. Plectoceras halli (Foord)
25. Plectoceras occidentale (Hall)
26. Plectoceras lowi Foerste
27. Eurystomites kelloggi (Whitfield)
28. Eurystomites chidleyense Foerste
29. Ophidioceras (?) sp. (Cornwallis Island)
30. Charactoceras schucherti Foerste
31. Actinoceras sp. (Bering Strait)
32. Kochoceras lenticulare Foerste
33. Kochoceras feildeni Foerste
34. Kochoceras mantelli Foerste
35. Kochoceras foordi Foerste
36. Ormoceras sp. (Arctic America)
37. Armenoceras lyoni (Stokes)
38. Armenoceras richardsoni (Stokes)
39. Armenoceras sphaeroidale (Stokes)
40. Armenoceras (?) ommaneyi (Salter)
41. Armenoceras cf. ommaneyi (Salter)
42. Armenoceras donetti Foerste
43. Armenoceras coppingeri Foerste
44. Armenoceras cf. rotulatum (Bilings)
45. Armenoceras sp. (Dobbin Bay)
46. Armenoceras naresi Foerste
47. Amenoceras sp. (Offley Island)
48. Huronia occidentale Foerste
49. Thuleoceras ornatum Troedsson
50. Amphicyrtoceras darwini (Billings)
51. Monocyrtoceras arcticum (Foord)
52. Westenoceras (?) tumidum (Schuchert)
53. Diestoceras schucherti Foerste
54. Manticoceras cf. pattersoni (Hall)

NEW GENERA

Cephalopoda

TROEDSSONOCERAS; genotype, *Orthoceras turbidum* Hall and Whitfield.

Conulariidae

METACONULARIA; genotype, *Conularia aspersa* Lindström.

1. **Endoceras chidleyense** Sp. nov.

Plate II, fig. 1; pl. XXII, figs. 1 A, B

Specimen 290 mm. long, the phragmacone being 167 mm. long, and the living chamber being 123 mm. in length. The upper part of the living chamber is broken off, and there is no means of determining its original total length. In the accompanying figure, only the lower part of the living chamber is included, and the figure of that part which is included is slightly larger than three-fifths of natural size. Since the uppermost camera is not shorter than those immediately beneath, the specimen may be not mature.

The diameter enlarges at the rate of 11 mm. in a length of 200 mm. At the top of the phragmacone its lateral diameter is 60 mm. The conch appears depressed dorso-ventrally. It is not known to what extent this depression is due to compression of the sediment in which the specimen was imbedded previous to fossilization.

Along the lower half of the phragmacone 6.5 camerae occupy a length equal to the diameter of the conch; near the top of the phragmacone this number increases to 7. The sutures of the septa are directly transverse. Where the diameter of the conch is 55 mm., the radius of concave curvature of the septa is 35 mm. At this point the distance from the siphuncle to the ventral wall of the conch is 5 mm., or slightly less. The lateral diameter of the siphuncle, in its present depressed condition, is 18 mm., and its dorso-ventral diameter is 14 mm., but originally its diameter probably was 18 mm. in both directions. In that case, the ratio of the diameter of the siphuncle to that of the conch was almost one to three.

The siphuncle is faintly annulated, the annulations occurring a short distance below the general concave curvature of the septa, where the outward curving lower margin of one septal neck comes in contact with the inward curving upper part of the septal neck immediately beneath. Each septal neck curves distinctly inward and downward at its origin from the septum immediately above; at its lower margin it curves slightly outward; the line of junction is at the base of the more rapidly contracting funnel-like part at the top of the neck. In exposing the siphuncle for study, the wall of the siphuncle appears to come loose in the form of a thin film whose sections apparently extend farther than the length of one camera, but this could not be verified in vertical sections, so that for the present the septal necks are regarded as extending only the length of 1 camera.

Locality and Horizon.—From Port Burwell, west of Cape Chidley, at the northern end of Labrador; in erratic blocks of limestone, regarded as of Black River age. Collected by A. P. Low in 1904. Numbered 7925 in the collections of the Geological Survey of Canada, in Victoria Memorial Museum.

Remarks.—*Endoceras chidleyense* differs from *Endoceras proteiforme* Hall chiefly in the much smaller size of its siphuncle, the siphuncle of the latter being one-half of the diameter of the conch in size.

2. **Endoceras baffinense** Sp. nov.

Plate VII, fig. 5

Cameroceras proteiforme Schuchert, Proc. U. S. National Museum, 22, 169 (1900).

Conch closely similar to *Endoceras proteiforme* Hall in its slow rate of enlargement, and in the relative number of camerae in a length equal to the diameter of the conch, but the siphuncle is relatively smaller and is farther from the ventral wall of the conch. In the specimen figured the diameter of the siphuncle is 19 mm. where that of the conch is 48 mm., and its distance from the ventral wall of the conch is 2.5 mm.

Locality and Horizon. From the head of Frobisher Bay, in Baffin Land; in strata regarded as Trenton; but possibly including also Richmond strata. Specimen No. 28191, in the U. S. National Museum.

3. **Cyclendoceras boreale** Sp. nov.

Plate I, fig. 1 A, B; pl. XXII, fig. 2 A, B

Orthocone enlarging at the rate of 15 or 16 mm. in a length of 200 mm. The specimen described here is a fragment of the phragmacone. It is 270 mm. long, and 50 mm. below its larger end its dorso-ventral diameter is 57 mm. The conch has been compressed laterally more or less by pressure.

Five camerae occupy a length equal to the diameter of the conch. The sutures of the septa slope downward from the dorsal toward the ventral side of the conch at an angle of 4 degrees with the horizontal. Where the diameter of the conch is 50 mm., the radius of concave curvature of the septa is about 32 mm. Along the narrow space between the siphuncle and the ventral wall of the conch the septa, as exposed in vertical sections, appear nearly straight but slant strongly downward, as might be expected from their close proximity to the wall of the conch.

The diameter of the siphuncle is equal to half the diameter of the conch or is but slightly less. Its distance from the ventral wall of the conch is about one-seventh of the diameter of the latter. The septal necks extend downward sufficiently to permit their lower edges to extend for a distance of 2 or 3 mm. into the top of the necks next beneath. At their origin from the septa the walls of these necks slope inward and downward for a distance of 2 or 3 mm. before becoming vertical. Moreover, that part of the succeeding neck which invaginates from above curves slightly outward on reaching the point where the walls of the neck beneath become vertical. The result is that the siphuncle appears transversely ridged by low annulations at points 2 to 3 mm. below the septa.

The thickness of the shell at the upper end of the specimen is

2 mm. at the annulations on its surface, and about 1 mm. thick in the intermediate depressions. About 8 annulations occur in a length equal to the diameter of the conch. Traces of these annulations appear on the cast of the interior of the conch, but are much less distinct here than on the surface of the shell. The annulations slope downward from the dorsal toward the ventral side of the conch at an angle of about 7 degrees with the horizontal.

Locality and Horizon.—From Port Burwell, a short distance west of Cape Chidley, at the northern end of Labrador; from erratic blocks apparently of Black River age. Specimen numbered 7922 and 7924 in the collections of the Geological Survey of Canada, in the Victoria Memorial Museum.

Remarks.—Compared with *Cyclendoceras annulatum* (Hall), from the Trenton at Middleville, New York, (pl. III, fig. 1), the rate of enlargement of the conch is about the same; the number of camerae in a length equalling the diameter of the conch is 5.5, instead of 8; the number of annulations in this length is 8, instead of 6.5; so that the number of annulations exceeds that of the camerae within the same length, instead of the reverse. Moreover, the diameter of the siphuncle, compared with that of the conch, is greater than in the New York species.

Compared with the specimen of *Cylendoceras* described and figured by Whiteaves[12] under the name *Endoceras annulatum* from the Nelson limestone, between the second and third rapids of the Nelson river, in the area west of Hudson Bay, in Canada, the conch enlarges much more rapidly; the number of camerae in a length equal to the diameter of the conch is 5.5, instead of 6.5; the number of annulations in this length is 8, instead of 5; these annulations slope downward at an angle of 7° degrees, instead of 22, beneath the horizontal; and the siphuncle is relatively larger. Whiteaves described the Nelson river specimen as a variety of *Endoceras annulatum* Hall, the generic name *Cyclendoceras* being proposed later by Grabau and Shimer.

[12] J. F. Whiteaves. The Orthoceratidae of the Trenton Limestone of the Winnipeg Basin. Trans. Royal Soc. Canada, 9, 77, pl. 5, figs. 1, 1a (1891).

4. Cyclendoceras sp. (Mount Beaufort)

Plate XI, fig. 1; pl. XXII, fig. 4

Specimen about 143 mm. long, apparently enlarging at the rate of 8 mm. in a length of 100 mm. Its lateral diameter at the uppermost point admitting of measurement in this direction is 73 mm., the dorso-ventral diameter at the same level being estimated at 65 mm. The specimen is crossed by 12 annulations in a length of about 117 mm. These annulations slope downward at an angle of about 77 degrees with the vertical axis, in a ventrad direction, their downward curvature increasing toward the median part of the ventral side of the conch. About 7.5 annulations occur in a length equal to the lateral diameter of the conch. The elevation of the crest of these annulations above the intermediate grooves is fully 2 mm.

The specimen has been cut both vertically and transversely. Both sections expose a lighter colored central portion surrounded by darker material, beyond which both lighter and darker material is present. The lighter colored central portion increases in diameter from 36 to 37 mm. at the base to 40 mm. at a point 75 mm. farther up. Along more than half of the circumference of this central portion its outline is circular, but along its ventral side its outline is more irregular, though a tendency toward a circular outline remains. This lighter colored central portion is regarded as locating the siphuncle. It is somewhat depressed dorso-ventrally, and its center is slightly ventrad of the center of the conch. The darker part immediately surrounding the lighter colored central portion is regarded as occupying that part of the camerae which is immediately exterior to the siphuncle.

The vertical outline of the supposed siphuncle is relatively straight; at least, no trace of nummuloidal structure has been detected. On the contrary, along the ventro-lateral part of the conch, on its right side, there apparently are traces of *Endoceroid* structure. These traces consist of the following features:

The dorsal side of the conch is strongly and irregularly weathered, sufficiently in places to have removed all traces of annulations. Nevertheless it is possible to trace annulations from the

relatively little weathered side, where the annulations are broadly rounded, into the weathered parts on its dorsal side, where the annulations tend to be sharply crested. Apparently these sharp crests are the edges of the septa which approximately coincide in their course with the annulations in that part of the specimen here under consideration. It appears possible to connect these supposed exterior margins of the septa with structures along the walls of the siphuncle in such a manner as to make the latter appear as parts of an *Endoceroid* conch. At several places the wall of the siphuncle appears to curve outward as though locating the upper part of the septal necks. This is true especially of the first, third, fourth, and fifth of the supposed septal necks, counting from the base of the specimen. These details are but vaguely defined, but, as far as can be ascertained from the single specimen at hand, the structure appears to be that of an endoceroid with a distinctly annulated exterior, as in *Cyclendoceras*.

Locality and Horizon.—This specimen bears the label: *Upper Silurian, Mount Beaufort, Arctic Am., Orthoceras . . . . by Capt. Belcher.* Two words formerly inserted between *Orthoceras* and *by Capt. Belcher* no longer are legible. In the British Museum of Natural History this specimen is numbered 96964, and it is there listed as *Orthoceras cf. thoas.*

Mount Beaufort is located directly north of the winter quarters of Capt. Belcher during the winter of 1852–53, while on his expedition in the "Assistance." The position of Mount Beaufort is indicated in Capt. Belcher's narrative, The last of Arctic Voyages, published in 1855, on the map facing page 90. It is situated at the northwestern limit of a bay known at that time as Northumberland Sound, south of the northwestern corner of a body of land at that time known as Prince Albert Land. At present this area is known as Grinnell Peninsula or Grinnell Land, and it forms the northwestern extension of North Devon Island. The location of these winter quarters was given as Lat. 77° 52 N., and Long. 97° W.; however, according to recent maps the latitude should have been 76° 52′ N., and the longitude as 96° 42′ W. There is a second Mount Beaufort in the American Arctic, on the northern coast of Grant Land, at the northern end of Ellesmereland, in latitude 82° 47′ N., and longitude 67° 2′ W.

Remarks.—*Orthoceras thoas* was described by Hall[13] from the lower half of the Middle Devonian of New York, where it occurs in the Schoharie and Onondaga members. It belongs to the genus *Spyroceras*, of which the genotype is *Orthoceras crotalum*, described by Hall.[14] This genus is characterized by the presence of strongly defined annulations, in addition to which there are distinctly defined vertical striae, and also much less distinctly defined but more numerous transverse striae. The transverse striae often are only obscurely preserved. The vertical striae are not strong enough to be compared with ribs, in the more typical species of the genus. The siphuncle is moniliform, its segments enlarging moderately within the camerae in a manner similar to *Sactoceras*. Similar species in which the more prominent vertical markings are comparable with ribs make their appearance as early as the Chazyan, where they are represented by *Spyroceras clintoni* (Miller); in the Black River and Trenton, by *Spyroceras bilineatum* (Hall); in the Richmond, by *Spyroceras hammelli* (Foerste); in the Brassfield, by *Spyroceras jamesi* (Hall and Whitfield); and they occur also in Clinton and in later Silurian strata.

The former comparison of the Mount Beaufort specimen, here described, with *Orthoceras thoas*, rather than with some Silurian or Ordovician genus and species suggests that this specimen was regarded formerly as of later age than the Silurian. On recent geological maps, the Mount Beaufort area is represented as covered by Carboniferous rocks, no Devonian or earlier strata being indicated on any part of the Grinnell peninsula. The comparison of the Mount Beaufort specimen with *Orthoceras thoas* apparently was based chiefly on the presence of relatively conspicuous annulations, and in the belief that the specimen was of Devonian age.

The present reference of the Mount Beaufort specimen to *Cyclendoceras*, an Ordovician genus, is based on the following considerations. Only a few annulated genera are known in which the siphuncle is as large as the supposed siphuncle of the Mount Beaufort specimen. All of these genera are either Endoceroids

[13] James Hall. Paleontology of New York, 5, pt. 2, 261, pl. 41 (1879).
[14] Idem, 296, pl. 42.

or Actinoceroids. Since the Mount Beaufort specimen shows no trace of nummuloidal structure it is regarded as an Endoceroid. At present all of the annulated orthoconic Endoceroids are placed in the genus *Cyclendoceras*, proposed by Grabau and Shimer for this group, with *Orthoceras annulatum* Hall as the genotype. This genus is well represented in the Black River, Trenton, and Richmond formations. It occurs in New York, and in the drift on Cape Chidley at the northern end of Labrador. But it is most common in that part of the Richmond which has Arctic affinities, in the area southwest of Hudson Bay, in the area including Boothia Felix and King William Land, in southern Manitoba, and in Idaho, South Dakota, and Wyoming; also in Wisconsin, Iowa, and Illinois.

Apparently the specimen here under consideration could have reached Mount Beaufort only as an erratic, but from what possible source at present is unknown.

5. **Orthoceras griffithi** Haughton

Plate XIV, fig. 4

Orthoceras griffithi Haughton, Jour. Royal Dublin Soc., 1, 239, pl. 5, fig. 1 (1857).

Orthoceras griffithi Foord, Cat. Foss. Cephalopoda British Museum, 1, 41 (1888).

The original description published by Haughton reads as follows:

> Testa cylindrato-conico; cella ultima omissa 6¾ uncias longa, $\frac{8}{10}$ uncias lata in parte inferiori; septis numerosis; cellis penultimis 2 lineas altis; marginibus orbiculatis; convexis, siphunculo centrali, simplici, 1½ lineas lato.

From the discussion, in English, which follows this inscription it appears that in a length of 2.5 inches the diameter of the fragment described increased from 0.5 inch at its smaller end to 0.8 inch at its larger end, and that in this length it included 15 camerae. From this it was calculated that the apical angle equalled 6° 52′, and that the total length of the phragmacone was estimated at 6¾ inches, and this final estimate is used in the Latin description. However, on examining the figure presented on the accom-

panying plate it is discovered that, although the diameter of the latter is 0.8 inch at the larger end of the figure, its diameter 2.5 inches farther down is 0.6 inch, resulting in an apical angle of about 5 degrees instead of one almost equalling 7 degrees. The number of camerae in a length of 2.5 inches, however, agrees with that given by Haughton in his English discussion, namely 15. The number of camerae occurring in a length equal to the diameter of the conch is 4.5, according to Haughton's figure. In this figure, moreover, the diameter of the siphuncle at the top of the specimen is 1.5 lines or 3 mm., and the segments of the siphuncle are figured as cylindrical, and not as enlarging distinctly within the camerae.

This specimen, figured by Haughton, appears to be lost. In Haughton's original description it is stated that *Orthoceras griffithi* is "found in great abundance at Griffith's Island, where Captain Austin's squadron wintered."

Remarks.—Since Haughton definitely figured the siphuncle of *Orthoceras griffithi* as having cylindrical segments, the name must be confined to specimens having siphuncles of this type, and can not be made to include those in which the segments of the siphuncle enlarge within the camerae in a moniliform manner, as in the genus *Sactoceras* of Hyatt.

Foord's Description.—The two specimens in the British Museum of Natural History which were referred by Foord rather doubtfully to *Orthoceras griffithi*, are there numbered C 2126a and C 2126b, and are described on the following pages in detail. These specimens consist in each case of a living chamber to which in one case a complete camera and a part of two more are attached, while in the second there is only a single camera. In the first specimen the length of the living chamber equals 2.3 times the diameter at its base. In the second specimen this ratio is 2.5; and in neither case does it equal 3, as stated by Foord. The statement that the septa are distant about one-fifth of the diameter and that the siphuncle is very excentric, about two-thirds along the diameter, is taken from the first specimen, though the actual position of this siphuncle is nearer two-fifths of the diameter. The statement that the surface is marked with fine,

close-set, thread-like lines or riblets, about 12 in the space of 1 line, is taken from the second specimen. Unfortunately the first specimen does not give any definite information as to the shape of the segments of the siphuncle, and the second specimen does not give even any information as to the location of its siphuncle. In fact, there is a possibility of the second specimen belonging to a different species from the first, and neither one is known to be identical with typical *Orthoceras griffithi*.

6. **Orthoceras** cf. **griffithi** Haughton

Plate XXII, fig. 5 A, B

Orthoceras Griffithi? Foord, Cat. Foss. Ceph. British Museum, 1, 41 (1888).

Orthoceras cf. *griffithi* Foerste, Jour. Sci. Labs. Denison Univ., 22, pl. 9, fig. 8; pl. 10, fig. 2 (1927).

Specimen consisting of a living chamber to which are attached one camera and lateral fragments of two additional camerae. The living chamber is 92 mm. in length, and enlarges from a diameter of 39 mm. at the base to a diameter estimated at 50 mm. at the top of this chamber, thus indicating an apical angle of about 7 degrees. The transverse section of the conch is circular.

The uppermost camera has a height of 7 mm., and approximately the same height is indicated by the lateral walls of the two underlying camerae, of which only the lateral part of one side remains. From this it is estimated that about five and a half camerae occupied a length equal to the diameter of the conch at the top of the series of camerae counted. The sutures of the septa are directly transverse. The septa are strongly concave, having a radius of curvature of 23 mm. The center of the siphuncle is located 16 mm., or two-fifths of the diameter of the conch, from the nearer wall of this conch. At the passage of the siphuncle through the septa, the latter curve downward, forming short septal necks, narrowing to 3 mm. in diameter. Apparently these necks are 1.2 mm. in length, and curve outward along their lower margin, attaining here a diameter of 3.7 mm. The rings

connecting successive septal necks are not clearly defined. They probably were approximately tubular or widened but slightly within the camerae. Such faint traces of markings as are seen within the vertical section of the single camera retaining the siphuncle are not symmetrical in form on the dorsal and ventral sides, and hence cannot confidently be interpreted as indicative of the real form of the segments of the siphuncle.

Locality and Horizon.—The specimen bears the label: *Griffith's Island, 1851*, with the letters *D* and *E* intertwined into a monogram. Only Silurian strata are recorded from this island. It is located south of the center of Cornwallis Island. Specimen No. C 2126a in the British Museum of Natural History.

Remarks.—Since the state of preservation of this specimen does not determine definitely that the segments of its siphuncle are cylindrical, rather than moniliform in outline, it is not safe to assume that the specimen here described belongs to *Orthoceras griffithi*. The most that can be said, in the absence of definite knowledge to the contrary, is that it *may* belong to that species.

7. **Orthoceras** (?) sp. (Cornwallis Island)

Orthoceras, sp. 1, Salter, in Sutherland's Voyage to Baffin's Bay and Barrow's Straits, 2, ccxxiii (1852).

The following is the description published by Salter:

One specimen of a species with the waved and flattish septa rather close, as in the last (*Orthoceras ommaneyi*), but not oblique, and with the siphon of small size and central.

Locality.—Cornwallis Island (Mr. Pickthorne).

8. **Ephippiorthoceras compressum** Sp. nov.

Plate VII, fig. 9; pl. XXIII, fig. 6

Conch with a very small apical angle, compressed laterally, with the sutures of the septa curving downward laterally, especially along the median part of these lateral sides. About 5 camerae occupy a length equal to the dorso-ventral diameter. The siphuncle is excentric in location, its center being located about 8 mm. from the ventral wall of the conch where its dorso-

ventral diameter is 22 mm. The diameter of the siphuncle is approximately 1.5 mm. at the septal necks, enlarging to 3 mm. within the camerae. No trace of markings on the surface of the shell remains.

Locality and Horizon.—From the head of Frobisher Bay, on Baffin Land; in strata regarded as of Trenton age; possibly including also Richmond strata. Specimen No. 38288A, in the U. S. National Museum.

9. **Ephippiorthoceras baffinense** Sp. nov.

Plate VII, fig. 8

Conch enlarging more rapidly than in the preceeding specimen, the lateral lobes of the sutures of the septa relatively shallow but much broader, siphuncle central in location. Its segments similar in form to the preceding specimen, slightly over 1 mm. in diameter at the septal necks, enlarging to 3 mm. within the camerae. Septal neck 0.3 mm. long on one side of the siphuncle and 0.6 mm. long on the other side. There is no trace of surface markings of the shell.

Locality and Horizon.—From the head of Frobisher Bay, on Baffin Land; in strata regarded as of Trenton age; but possibly including also Richmond strata. Specimen No. 33288B, in the U. S. National Museum.

10. **Sactoceras** (?) sp. (Griffith Island)

Plate XI, fig. 4; pl. XXII, fig. 3 A, B

Orthoceras Griffithi? Foord, Cat. Foss. Ceph. British Museum, 1, 41 (1888).

Specimen consisting of the living chamber with one camera still attached. The living chamber is 54 mm. in length, and enlarges from a diameter of 22 mm. at the base to 26 mm. at the top, thus indicating an apical angle of four and a half degrees. The cross-section of the conch is circular.

The uppermost camera has a height of 2 mm. Since the uppermost camera of mature cephalopods often is considerably shorter

than those camerae which are immediately beneath, there is no means of determining the average length of the latter compared with the diameter of the conch. The sutures of the septa are directly transverse or deviate from this course but slightly. The septa are strongly concave, having a radius of curvature of 15 mm. The siphuncle cannot be located with confidence. Almost all of the septum at the base of the specimen is preserved and is exposed clearly. All of this preserved part is evenly convex and does not suggest by any deviation from this convexity the presence of a siphuncle. Along one side of the specimen, a fragment 16 mm. in width, at no point extending farther than 6 mm. from the nearest wall of the conch, is missing. If the siphuncle was located within this missing part, its center must have been 5 mm. or less from the nearest wall of the conch, which is relatively a much shorter distance than that shown by the siphuncle of the *Orthoceras* numbered C 2126a, and described on the preceding page from the same locality and horizon.

Most of the single camera belonging to the specimen is filled by a black deposit, but the latter is interrupted on one side by a light colored mass only approximately circular in outline. This light colored mass is 6 or 7 mm. in diameter and is 2 mm. distant from the nearest wall of the conch. If this light colored mass indicates the former location of the siphuncle, then this specimen might be related to the specimen numbered 96966, from Cornwallis Island. It must be admitted, however, that such a correlation cannot be regarded as certain.

The shell of this specimen apparently was thick and its surface was smooth. The outer surface of one of the innermost layers however, was finely striated transversely, 8 or 9 striae occupying a length of 1 mm.

Locality and Horizon.—This specimen bears the label; *Griffith's Island, Orthoceras, 1851*, and the letters *D* and *E* intertwined into a monogram. Only Silurian strata are known from this island. Specimen No. C 2126b in the British Museum of Natural History.

Remarks.—In the absence of definite knowledge of the location and structure of its siphuncle, this specimen cannot be determined

even generically. Although resembling *Orthoceras griffithi* in form, there is a possibility of its being an actinoceroid. This possibility is suggested by a circular area of brownish matrix, 6 mm. in diameter, whose nearest margin is 2 mm. from the wall of the conch in the only camera preserved. Surrounding most of this brownish area is a lighter colored matrix forming a circular band with a width of 1 mm., and surrounding the latter is the black matrix which fills the remainder of the camera. If the brownish part of the matrix locates the siphuncle, then the latter may be actinoceroid, possibly belonging to the genus *Sactoceras* of Hyatt.

It should be noted that the very fine transverse lines noted by Foord occur only on the shell of this smaller, doubtfully identified, specimen, and are not preserved on the larger specimen which is regarded as more directly comparable with *Orthoceras griffithi*.

11. **Sactoceras** (?) sp. (Griffith and Cornwallis Islands)

Orthoceras, sp. 2, Salter, in Sutherland's Voyage to Baffin's Bay and Barrow's Straits, 2, ccxxiii (1852).

The following is the description published by Salter:

> Long and very slowly tapering. The septa much more distant than in the last two. In the largest specimen, three-quarters of an inch wide, they are frequently more than two lines apart, and very convex. The siphon is considerably out of the middle, and is small where it joins the septum, but is welled into a bead-like shape between them. It is probably an *Ormoceras*.
>
> Localities.—Plentiful in Griffith's and Cornwallis Islands.

This description is of interest chiefly because it suggests the presence at Griffith's Island of a species which may resemble *Orthoceras griffithi* exteriorly, but which has a distinctly different type of siphuncle within its interior.

DAWSONOCERAS Hyatt

Genotype: *Orthoceras annulatum*, in Museum of McGill College, Montreal; same specimen described here as *Dawsonoceras hyatti*.

The genotype of *Dawsonoceras* is not the *Orthoceras annulatum* of Sowerby but an altogether different specimen which was identi-

fied as *Orthoceras annulatum* in the Redpath Museum at McGill College, in Montreal, Canada. The latter is regarded as forming a distinct species and therefore is described here as *Dawsonoceras hyatti*. Fortunately this does not change in any way our conception of the genus, since the McGill college specimen presents the same generic features as Sowerby's type of *Orthoceras annulatum*, though not specifically identical.

Since the characteristic feature of *Dawsonoceras* consists in the presence of frills in the transverse striae, it is impossible to determine in some cases whether certain specimens which do not preserve their surface ornamentation are to be referred to *Dawsonoceras* or *Spyroceras*. When the siphuncle is not preserved, they may even resemble *Cyclendoceras*.

The present writer, for example, identified as either *Cyclendoceras* or *Dawsonoceras* a specimen collected at some unknown locality in either Boothia Felix or King William Land by the Gjoa expedition.[15] However, so far, no specimens of *Dawsonoceras* have been discovered in Ordovician strata in America, and since all the cephalopods associated with the doubtful form from the Boothia Felix-King William Land area are of Ordovician age, the possibility of the specimen in question being a *Dawsonoceras* may be excluded.

Unfortunately, the erroneous suggestion that the Gjoa expedition specimen might belong to *Dawsonoceras* led astray the very careful observer Gustaf Troedsson, who, in his recent studies of the cephalopods in the Middle and upper Ordovician faunas of Northern Greenland[16] described one form as *Dawsonoceras ? aquilonare*. The siphuncle of the latter excludes it definitely from *Cyclendoceras*. However, in the absence of any knowledge of its surface ornamentation it cannot be determined definitely whether this specimen is to be referred to *Dawsonoceras* or *Spyroceras*. Since the specimen was found in strata of Ordovician age, it is not likely to be a *Dawsonoceras*. Hence the generic reference

[15] Aug. F. Foerste. Notes on Arctic Ordovician and Silurian Cephalopods. Jour. Sci. Labs. of Denison Univ., 19, 301, pl. 31, fig. 2 (1921).

[16] Gustaf T. Troedsson. On the Middle and Upper Ordovician Faunas of Northern Greenland, pt. 1, Cephalopods, 35, pls. 9, 10 (1926).

to *Spyroceras* is preferable tentatively, especially in view of the fact that specimens of *Spyroceras* which have an aspect similar to that of *Dawsonoceras*, when deprived of their surface ornamention, are known from the Ordovician. Of these, the one must closely resembling *Dawsonoceras* ? *aquilonare* Troedsson is an undescribed species, *Spyroceras microlineatum*, from the English Head and Vaurial formations of Anticosti. In this specimen the inner layers of the shell are ornamented by very numerous vertical raised lines, about 11 in a width of 1 mm. The type specimen is from Cape Henry, in zone 3 of the Vaurial formation, and is numbered 3835 in the collections at Yale. It is assumed that these vertical raised lines appear also at the surface of the shell. In that case, the reference of the Anticosti specimens to *Spyroceras* would appear warranted. The pertinency of this comparison is increased by the fact that the Anticosti specimens come from the English Head and Vaurial members of the Richmond, while the North Greenland specimens are from the Cape Calhoun series, which also are of Richmond age. Hence, until specimens preserving the surface ornamentation are found in the North Greenland beds it appears advisable to refer the *Dawsonoceras* ? *aquilonare* tentatively at least to the genus *Spyroceras*.

12. **Dawsonoceras hyatti** Sp. nov.

Plate IV, fig. 2; pl. XXVIII, fig. 6

Dawsonoceras annulatum Hyatt, Proc. Boston Soc. Nat. Hist., 22, 276 (1884); type at McGill College, Montreal.

Specimen 165 mm. long, enlarging from a diameter of 45 mm. at the fifth annulation above the base to 47 mm. at a point 110 mm. farther up, but the specimen is slightly flattened toward the top, so that the rate of enlargement evidently is small. The number of annulations in a length equal to the diameter of the conch is 6, except at the base of the specimen where 6.5 annulations occupy this length. The width of the annulations is 4 mm. while that of the intermediate grooves is 5 mm., measured in a vertical direction. The slope of the annulations is slightly steeper along their lower sides than on their upper sides. The elevation of the crest

of the annulations above the intermediate grooves varies from 1.25 to 1.33 mm. In addition to the annulations there are frilled transverse striae. Usually 5 or 6 of these striae occupy the grooves between the annulations, and about the same number occur on the annulations, but here they tend to be more closely crowded together. Ten frills occur in a width of 12 mm., counted in a direction transverse to the length of the conch. Usually the upward curved part of these striae tends to be curved more narrowly than the downward curved part, but frequently no difference whatever can be observed locally. Along the upward curved parts of the transverse striae the surface of the shell tends to be elevated into narrow vertical riblets, which escape attention except under transverse illumination and with the assistance of a lens.

Locality and Horizon.—The specimen is labelled *Niagara. Hamilton, Ont. Donor: Lt. Col. Grant.* It evidently was found in the Niagaran at Hamilton, Ontario. The matrix consists of a light colored rock, evidently the Lockport dolomite. The shell itself is represented only by a dark-colored film. The specimen is numbered 2648 in the collection at McGill College.

Remarks.—In the general appearance of its transverse striae *Dawsonoceras hyatti* resembles those of *Dawsonoceras crassum* (Foord).[17] However, in the American species here described these striae are not lamellose; they tend to be more numerous in the grooves between the annulations, and their frills are distinctly narrower, measured in a direction transverse to the length of the conch.

13. **Dawsonoceras granti** Sp. nov.

Plate IV, fig. 1; pl. XXVIII, figs. 5 A, B

Specimen 220 mm. in length, flattened by pressure, enlarging in its present condition from a diameter of 60 mm., measured along the crest of an annulation, to 65 mm. in a length of 160 mm., thus indicating an apical angle of about 2.5 degrees. In this length of 160 mm. there are 13 transverse annulations, or almost 6

[17] A. H. Foord. Catalogue of Fossil Cephalopoda in the British Museum, pt. 1, 53, text fig. 4 (1888). See also pl. VI, fig. 4 of present article.

annulations in a length equal to the diameter of the conch. The annulations are 4 or 5 mm. wide in a vertical direction, and are separated by intermediate grooves 8 or 9 mm. in width. The annulations are prominent, and rise about 2 mm. above the deepest part of the intermediate grooves. Above the length of 160 mm. within which the annulations are strongly defined, there is an additional length of nearly 60 mm. within which well defined annulations are absent, though a transverse wrinkling of the shell remains. The most distinct of these transverse wrinkles is located about 14 mm. above the uppermost well defined annulation, and this wrinkle represents a partially successful attempt at another annulation. In addition to annulations, the entire surface of the shell is ornamented with transverse striae. In the concave spaces between the annulations, these transverse striae occur at intervals varying from 1 to 1.5 mm., but on the crest of the annulations these intervals often are only four-fifths of a millimeter or slightly less. In the upper, gerontic part of the conch, where the annulations are absent, the transverse striae tend to be more crowded, varying from four-fifths to a whole millimeter apart along the lower half of this gerontic part, but becoming more irregular and less clearly defined along its upper part. In the annulated part of the specimen the transverse striae are frilled or festooned. The individual frills average about 4 mm. in width, measured in a direction transverse to the length of the conch. The rising or elevated parts of the frills are more narrowly rounded than the sagging or concave parts of the frills. These sagging parts of the frills occupy the crests of relatively low and broad vertical ribs, while their rising or elevated parts occupy the much narrower intermediate vertical grooves. The frills of the transverse striae, and the vertical ribs and intermediate vertical grooves are more or less clearly defined also along the lower part of the gerontic portion of the conch, where the distinct annulations are absent. However, farther up these features become less distinct, and at the aperture they are virtually absent. It is impossible to determine how much of the length of this specimen belongs to the living chamber.

Locality and Horizon.—The label accompanying this specimen

reads: *Niagara, Barton, Niagara, Ont., Donor: Lt. Col. Grant.* This has been assumed to mean that the specimen was found in the Barton member of the Niagaran, in the vicinity of Niagara Falls, in Ontario. According to Prof. M. Y. Williams (The Silurian Geology and Faunas of Ontario Peninsula, and Manitoulin and Adjacent Islands, Mem. 111, Geol. Surv. Canada, 1919, p. 61), the upper 80 or 90 feet of the Lockport, overlying the chert beds and underlying the Guelph dolomite in the vicinity of Hamilton, are decidedly argillaceous and contain shale beds at some horizons. These beds were called the "Barton beds" by Spencer and Grant, after the name of the township in which Hamilton is located. The upper 35 feet of these Barton beds are at present referred to the Eramosa member. The specimen here described as *Dawsonoceras granti* is embedded in a blackish shaly rock. It is numbered 2644 in the collections of McGill College.

Remarks.—The chief characteristics of *Dawsonoceras granti* are the broad vertical ribs, separated by relatively narrow vertical grooves. The annulations are prominent, and the frills of the transverse striae are relatively wide, though not as wide as in typical *Dawsonoceras americanum*. Moreover, contrasted with the latter species, the upwardly curved parts of these frills are more narrowly rounded.

Dawsonoceras bartonense Spencer.—The original description of this species is as follows:[18]

This shell is cylindrical, small, and tapering very slightly. The siphuncle is apparently subcentral. The surface is strongly annulated, and the crests are somewhat angular and situated at about 2.5 millimeters apart. The annular crests are marked by swelling waves (giving a nodular appearance on the margin), whose centers are closer than the distances between the crests of the rings. The surface of the shell is slightly striated parallel with the wave-like markings just mentioned. The calcareous matter is partly preserved, but only a portion of shell about five centimetres long was obtained. Its diameter is about one centimetre. *Formation and Locality.*—This species occurs in the "chert bed" of the Niagara formation at Hamilton, Ont.

[18] J. W. Spencer. Niagara Fossils. Bull. Missouri State Mus., 1, 60, pl. 7, fig. 7 (1884). Reprinted in Trans. Acad. Sci. St. Louis, 4 (1884).

Remarks.—The figure accompanying this original description of *Orthoceras bartonense* Spencer is 38 mm. long, and 10 mm. in diameter. The crests of the annulations are from 3.5 to 4 mm. apart, the latter number predominating. This indicates only about 3 annulations in a length equal to the diameter of the conch, or a number slightly less than 3. The individual frills or scallops are drawn as though about 3 mm. in width, so that 10 or 11 might be expected within the circumference of a conch at that stage of growth. The annulations are relatively prominent and angular. Compared with *Dawsonoceras granti*, the annulations of *Dawsonoceras bartonense* are remarkably more distant from each other, in view of the small diameter of its conch. It is assumed that the "chert bed" designated as the horizon of *Dawsonoceras bartonense* is that immediately beneath the "Barton Beds" in the Lockport from which *Dawsonoceras granti* was obtained.

14. **Dawsonoceras annulatum** (Sowerby)

Plate V, fig. 1 A; pl. XXVIII, fig. 7

Orthocera annulata Sowerby, Min. Conch., 2, 73, pl. 133 (1816).
Orthoceras annulatum Blake (pars), British Foss. Cephalopoda, pt. 1, p. 89, pl. 4, fig. 3 (Sowerby's type).
Orthoceras annulatum Foord, Cat. Foss. Cephalopoda British Museum, pt. 1, 53, text fig. 4a 4a′ (1888).

Specimen 110 mm. long, enlarging from a lateral diameter of 27 mm. at its base to 34 mm. at a point 80 mm. farther up. The corresponding dorso-ventral diameters are 25 mm. and 29 mm. The conch may be slightly depressed dorso-ventrally by pressure previous to fossilization. The concavity of the septum at the base of the specimen is about 7 mm. The suture of this septum appears to slope slightly downward in a ventrad direction, but at a distinctly smaller rate than the annulations. The location of the siphuncle is central, and its passage through the septum mentioned is approximately 2.5 mm. in diameter. The surface of the shell is annulated transversely, 7 annulations occurring in a length equal to the lateral diameter of the conch. These annulations slope downward in a ventrad direction at an angle varying

from 8 degrees at the base of the specimen to 10 degrees at its top, when compared with the horizontal. The annulations are relatively prominent, and rise fully 1 mm. above the intervening grooves. Their width, in a vertical direction, is almost 2 mm., where the width of the intervening grooves is slightly over 3 mm. The annulations are ornamented by about 6 closely arranged transverse striae which occupy the crest and upper side of these annulations, along a vertical width of from 1.5 to 1.8 mm. The grooves are occupied by 6 or 7 more distantly spaced transverse striae, distributed over a width of 3 mm., of which the uppermost striation usually is a short distance up the slope of the lower face of the annulations. The crowding of the striae on the annulations is far greater than in any species of *Dawsonoceras* studied so far in American Silurian formations.

Locality and Horizon.—Coalbrookdale, in Shropshire, England; from the Wenlock member of the Silurian. Unfortunately, Sowerby assigned his species erroneously to the Carboniferous Limestone (Derbyshire Peak Limestone), in the "Supplementary Index" to vol. 2 of the Min. Conch., cited above. This led many to suppose that Sowerby's type of *Dawsonoceras annulatum* was a Carboniferous species. But Professor Prestwich,[19] in his paper "On the Geology of Coalbrookdale" records it from the Wenlock and other Silurian rocks of that district, so that its Silurian horizon no longer is under doubt. Specimen No. 43849 in the British Museum of Natural History.

Remarks.—Along the upper part of the specimen, for a length of 17 mm., the annulations are almost obsolete. Usually, this is an indication of gerontic stages of growth. Foord states that "these ribless intervals—are succeeded in some examples by a ribbed surface of indefinite length." This is an interesting illustration of rejuvenescence, but does not controvert the fact that in *Dawsonoceras*, as well as in *Spyroceras*, the annulations often become partially or entirely obsolete at gerontic stages of growth.

In his figure 4a Foord attempted to show the great contrast between the very crowded striae on the surface of the annulations

[19] Prestwich. On the Geology of Coalbrook Dale. Trans. Geol. Soc. London, 5, pt. 3, 422 (1850).

and their greater spacing within the grooves with the unfortunate result that the annulations appear so much darker than the intermediate grooves that they might be interpreted as narrow grooves themselves. Moreover, the vertical ribbing of spaces between the annulations apparently is greatly over-accentuated, judging from an excellent cast of the lower part of the ventral side of the type presented to me by Dr. F. A. Bather.

It has so long been customary for American paleontologists to identify almost all American species of *Dawsonoceras* with Sowerby's species that it will take a long time to drop this name from American nomenclature, but I have never seen an American specimen which could be identified with the latter.

14a. **Dawsonoceras americanum** (Foord)

Plate VI, fig. 4; pl. XXVIII, figs. 4 A, B

Orthoceras annulatum var. *Americanun* Foord, Catalogue of Fossil Cephalopoda in British Museum (Natural History), pt. 1, 56, text fig. 4c on p. 53 (1888).

Original description.—

The characters by which the variety *Americanum* is distinguished from its European allies reside in the surface ornaments. These consist of transverse elevations, partaking more of the nature of undulations than of ribs, and becoming in some places indistinct, or even obliterated. The undulations are generally wider than the spaces separating them, being at a distance of about ½ the diameter. The fimbriae are coarse, as in the variety *crassum*, but with their arches or festoons much wider apart. Three or four only occupy the spaces between the undulations. The longitudinal elevations are sometimes so strong as to cause a nodose appearance; but this is not always the case, as I have a specimen before me in which they are very obscure. The rate of tapering in a somewhat flattened example from Canada, measured along its broader diameter, is 1 in 17. *Horizon.* Niagara Group (Wenlock).

Localities.—Canada; Lockport, New York State; Ripley County, Indiana. The specimen from Canada was presented by the late Dr. J. J. Bigsby, F.R.S.

Regarding the three specimens mentioned by Foord, Dr. F. A. Bather supplies the following information:

In reply to your query about *Orthoceras annulatum var. Americanum*, the transverse striae figured on page 53 could have been taken from either of the three specimens mentioned in Foord's Catalogue (cited above). The specimen said by

Foord to have come from Canada bears no original label, neither is any locality recorded in our Register, and as the matrix is very like that of our common Wenlock and Ludlow fossils, and unlike that of any of our American specimens, it is very doubtful if the specimen is a Canadian fossil. It would be better to select one of the other specimens as a holotype. I suggest C. 2135, which is in black limestone from Lockport.

This suggestion of Dr. Bather is followed here. The holotype, therefore, is that specimen studied by Foord which came from the Rochester shale member of the Niagaran at Lockport, New York. The Ripley county specimen came from the Osgood member of the Niagaran in Indiana, which corresponds essentially to the Rochester shale at Lockport. Both the specimens from the Rochester shale and those from the Osgood member are well represented in American collections, and are closely similar, except that the Osgood specimens always are smaller in size.

In his synonomy of *Dawsonoceras americanum*, Foord includes erroneously various specimens of *Dawsonoceras* figured by various authors from the Brownsport of Tennessee, the Racine of Wisconsin, the Cedarville of Ohio, and the Guelph of Ontario. This accounts for that part of his original description of *Dawsonoceras americanum* which states that *the longitudinal elevations are sometimes so strong as to cause a nodose appearance.* This statement applies to *Dawsonoceras nodocostatum* (McChesney), from the Racine and Cedarville, rather than to *Dawsonoceras americanum.*

Figure 1a on plate 64 of volume 1 of the Paleontology of New York is an excellent representation of the Rochester shale form, here accepted as typical. The specimen represented came from Lockport, New York, but is figured in an inverted position, with its apical end toward the top. Hence, the festoons formed by the transverse striae curve upward, instead of downward. Typical specimens of *Dawsonoceras americanum* occur not only in Ripley county, but also in all the other counties in Indiana and in the adjacent part of Kentucky in which the Osgood member of the Niagaran is exposed. Both in the Rochester shale and in the Osgood formation specimens of *Dawsonoceras americanum* occur in which the transverse striae are as numerous as in the variety *subtile* (Pl. VI, fig. 5 of present article) figured by Foord. In these specimens the transverse striae often are almost straight,

and the so-called festoons are virtually obsolete. Moreover, specimens are not uncommon in which the festoons appear on one part of the specimen but are replaced by numerous nearly straight lines on another part of the same specimen. However, where the specimens are at all common, the festoons appear frequently enough to identify the species. The annulations in typical *Dawsonoceras americanum* usually are much weaker than in most other American species of *Dawsonoceras*.

The species described by Troost as *Orthoceratites Defrancii* was a form of *Dawsonoceras*. It was obtained in the Brownsport division of the Niagaran in Perry county, Tennessee, where it was associated with the species identified by Troost as *Calceola sandalina*, later differentiated by Roemer as *Calceola tennesseensis*. This coral is characteristic of the upper part of the Lobelville member of the Brownsport formation. The specimen of *Dawsonoceras* figured by Roemer under the name *Orthoceras annulatum* (Die Silurische Fauna des Westlichen Tennessee, p. 78, pl. 5, figs. 18a, 18b (1860)), from the Silurian of western Tennessee, probably came from the same horizon as Troost's specimen, but was much smaller in diameter. Unfortunately, neither the specimen figured by Troost nor that figured by Roemer preserved the surface of their shells, but other specimens collected at the same horizon are not of the *Dawsonoceras americanum* type.

15. **Spyroceras baffinense** (Schuchert)

Orthoceras olorus Hall, var. *baffinensis* Schuchert, Proc. U. S. National Museum, 22, pl. 12, figs. 19–22 (1900).

Conch sharply annulated, the annulations being much narrower than the flattened intermediate grooves. Surface with 6 very fine vertical raised lines in a width of 2 mm., the intermediate spaces being occupied by 3 to 5 still finer vertical lines. The transverse striae are exposed at only one point where they cross the groove between two of the secondary vertical raised lines transversely. Here they occur at about the same rate as the secondary raised lines, or are slightly less frequent than the latter. The siphuncle is central in location.

Locality and Horizon.—From the head of Frobisher Bay, on

Baffin Land; from strata regarded as of Trenton age; but possibly including also Richmond strata. Specimen No. 28192, in the U. S. National Museum.

16. **Spyroceras porteri** (Schuchert)

Plate VII, figs. 2 A, B; pl. XXIII, fig. 4

Orthoceras porteri Schuchert, Proc. U. S. National Museum, 22, p. 169, pl. 12, figs. 23–25 (1900).

Surface with about 5.5 annulations in a length equal to the diameter of the conch; also with numerous vertical raised lines, which can be differentiated, according to size, into 3 series, the more prominent ones being called primary ribs. Between the latter is an equal number of less prominent secondary riblets, and between each adjoining primary and secondary rib or riblet there is a tertiary raised line. The crests of the ribs and riblets are relatively narrow, and, when weathered away, leave the double crested appearance noted by Schuchert. The transverse striae are sharply defined and number 5.5 to 7 in a length of 1 mm. The concavity of the septa is 1.5 mm. Where the diameter of the conch is 13.2 mm., the center of the siphuncle is 4.5 mm. from the ventral wall of the specimen. The siphuncle is 0.6 mm. in diameter at the septal necks, expanding to 1.25 mm. within the camerae.

Locality and Horizon.—From the head of Frobisher Bay, on Baffin Land; in strata regarded as Trenton; but possibly including also Richmond strata. Specimen No. 28194, in the U. S. National Museum.

Specimen No. 28193, in the U. S. National Museum, identified by Schuchert as *Orthoceras bilineatum* Hall[20] is another specimen of *Spyroceras*.

17. **Kionoceras** cf. **myrice** (Hall and Whitfield)

Plate X, fig. 3

Orthoceras Darwini Foord, Cat. Foss. Cephalopoda British Museum, pt. 1, 76, test fig. 8 (1888).

[20] Charles Schuchert. On the Lower Silurian (Trenton fauna) of Baffin Land. Proc. U. S. National Museum, 22, 169 (1900).

Specimen 95 mm. long, faintly curved lengthwise, the right outline of the specimen as figured being slightly convex. In its present condition one side of the specimen is strongly crushed inward, but the side figured is but slightly distorted. This side increases in lateral diameter from 13 mm. at its base to 26 mm. at its top, the interval being 84 mm. The number of camerae in a length equal to the diameter of the conch increases from 7 at the lower end of the specimen to 8.5 at its top. The sutures of the septa are directly transverse. On that half of the specimen which is well preserved there are 14 distinct vertical ribs; from this it is assumed that 27 or 28 ribs occurred within the circumference of the upper end of the specimen. A small part of the shell is preserved along the upper part of the left side of the specimen as figured, and this part shows that ribs were more angular and more prominent on the surface of the shell than on the surface of the cast of the interior. The more minute markings on the surface of the shell are not preserved. There is no trace of transverse raised lines occurring at rhythmical intervals, as in figures 7, 10, and 11 on plate 19 of the 20th Report of the New York State Cabinet of Natural History, published by Hall in 1868. On the contrary, there appear to be vague traces of fine longitudinal lines, as in figure 6 on the plate just cited.

Locality and Horizon.—Offley Island, in Kennedy Channel, Arctic America, at latitude 81° 16′ north; in the Niagaran division of the Silurian. Specimen C 2143 in the British Museum of Natural History.

The reference of the Offley Island specimen to *Orthoceras Darwini* Billings is in error, as indicated by the description of the latter presented under *Amphicyrtoceras darwini* (Billings) on one of the following pages of this publication. Its reference to *Cyrtoceras myrice* Hall and Whitfield is at least generically correct,the latter being a true *Kionoceras*. It agrees, moreover, in the number of vertical ridges. The type of *Cyrtoceras myrice* is described as having 27 of these ridges, but their number varies from 25 to 29 in different specimens. In the type specimen there were about 6 camerae in a length equal to the diameter of the conch, but in numerous other specimens collected from the same horizon and

in the same general area as the type the number of camerae more commonly varies between 7 and 8.5 in a corresponding length.

Kionoceras myrice is not the only American species of *Kionoceras* having about 27 or 28 vertical ribs. Species with this number of ribs include also *Kionoceras scammoni* (McChesney), 1861; *Kionoceras columnare* (Hall), 1860; and *Kionoceras woodworthi* (McChesney). But of these species, *Kionoceras scammoni* is described as having about 4 camerae in a length equal to the diameter of the conch, the surface of the shell having transverse raised lines; *Kionoceras columnare* also may have 4 camerae, but usually has less than 4 in a corresponding length, the surface of the shell being striated as well as ribbed in a vertical direction; and *Kionoceras woodworthi* has about 7 or 8 camerae in a corresponding length, but nothing is known of the finer ornamentation of the surface of its shell. The annulations on the surface of the species named last may be aberrant irregularities of growth, not characteristic of the species as a whole. In the absence of the type it probably never will be possible to determine precisely what species formed the basis of McChesney's *Kionoceras woodworthi*, but this is the only described American species which is similar to *Kionoceras myrice* both in the number of vertical ribs and in the number of camerae in a length equal to the diameter of the conch.

Provisionally, therefore, the Offley Island specimen is referred to *Kionoceras myrice*, though a definite identification is impossible until the character of the finer markings on the surface of the Offley Island specimen and on the surface of typical specimens of the Ohio species *Kionoceras myrice* is known.

18. **Kionoceras scalariforme** (Schuchert)

Plate VII, fig. 1

Orthoceras scalariformis Schuchert, Proc. U. S. National Museum, 22, 170, pl. 12, figs. 17, 18 (1900).

Conch enlarging at an apical angle of 7 degrees, section originally circular, surface with 13 prominent vertical ribs, usually with three vertical secondary raised lines in the intermediate

spaces. Also with a number of strongly elevated, relatively sharp transverse annulations, which tend to occur at rhythmic intervals. According to Schuchert, one of these occurs to each septum, but they are absent locally, and it is not certain that they are not due to some pathological condition of the conch. The siphuncle is excentric in location, but not in contact with the wall of the conch. Its segments are approximately globular in form, producing a moniliform type of siphuncle.

Locality and Horizon.—From the head of Frobisher Bay, on Baffin Land; in strata regarded as of Trenton age; possibly including also Richmond strata. Specimen No. 28195 in the U. S. National Museum.

TROEDSSONOCERAS Gen. nov.

Genotype: *Orthoceras turbidum* Hall and Whitfield, Geol. Surv. Ohio, Pal. 2, 100, pl. 3 fig. 1 (1875).

The genus *Kionoceras* was established by Hyatt[21] on *Orthoceras doricum* Barrande,[22] from the Silurian of Bohemia. Two distinct types of surface structure are included under this name. The specimen represented by figure 1 has primary vertical ribs, separated by concave vertical grooves each of which is occupied by about 3 equally spaced secondary vertical raised lines. These are further illustrated in figures 4 and 5. In figure 9, on the contrary, there are no conspicuous secondary vertical raised lines, and this type of structure is further illustrated by figures 12 and 13. In both types of structure there are numerous transverse lines. The first type of structure evidently leads directly to that characteristic of *Protokionoceras*, as defined by Grabau and Shimer,[23] based on *Orthoceras medullare* Hall.[24] Forms of this type usually have cylindrical segments of the siphuncle, and are common in the Silurian.

In the species originally described as *Orthoceras turbidum* the

[21] Alphaeus Hyatt. Genera of Fossil Cephalopods. Proc. Boston Soc. Nat. Hist., 22, 275 (1884).

[22] Joachim Barrande. Systeme Silurien du Centre de la Boheme, vol. 2, Cephalopoda, pt. 3, pl. 269 (1874).

[23] Grabau and Shimer. North American Index Fossils. 2, 58 (1910).

[24] James Hall. 20th Report of the New York State Cabinet of Natural History, 354, pl. 19, figs. 1–3 (1868).

vertical ribs are more numerous, and are about as wide as the intermediate vertical grooves, their crests being rounded. Corresponding ribs are present on casts of the interior of the conch. In the specimens from Cumberland River, the surface of the shell appears smooth, aside from these vertical ribs. Some of those from the Cincinnati area have one or more narrow raised lines between the vertical ribs. The siphuncle is moniliform, its segments being approximately globular in form, and strongly constricted at the septal necks, which are distinctly defined, but of moderate length. This species was described from the Fairmount member of the Maysville formation in the vicinity of Cincinnati, Ohio. It occurs also at the same horizon along the Cumberland River, in south-central Kentucky.

In this genus are included also the species described by Troedsson,[25] under the names *Sactoceras striatum* and *Sactoceras* (?) *lineatum*, from the Richmond division of his Cape Calhoun series, on the northeastern shore of Kane Basin, in northwestern Greenland. The Fairmount species is selected as a type since specimens of it are more ready of access.

19. **Troedssonoceras turbidum** (Hall and Whitfield)

Plate VI, fig. 2; pl. XXIII, fig. 9

Orthoceras turbidum Hall and Whitfield, Geol. Surv. Ohio, Pal., 2, 100, pl. 3, fig. 1 (1875).

Specimen about 100 mm. long, circular in cross-section, with its lateral diameter enlarging from 30 mm. at its base to 34 mm. at a point 60 mm. farther up. The number of camerae in a length equal to the diameter of the conch varies from almost 5 at the lower end of the specimen to 4.4 farther up. The sutures of the septa curve downward in a ventrad direction for a distance equalling approximately the length of 1 camera. The concavity of the septa equals about 4 or 5 mm. The passage of the siphuncle through the septum is 5 mm. in diameter, and the center of this siphuncle is located at 13 mm. from the ventral wall of the conch where the dorso-ventral diameter of the latter is 30 mm. The

[25] Gustaf T. Troedsson. On the Middle and Upper Ordovician Faunas of Northern Greenland, pt. 1, Cephalopods, 79, 80, pl. 1, fig. 7, pl. 47, figs. 1–3, 4–7 (1926).

segments of the siphuncle enlarge within the conch to an approximately globular form, being 7.5 mm. in diameter where the diameter of the conch is 34 mm. The specimen consists of a cast of the interior of the conch, and its surface is ornamented with low, vertical ribs, about as wide as the intervening vertical grooves, of which between 48 and 50 occur within the circumference of the conch. These ribs appear to be equal in size.

A second specimen, 145 mm. long, enlarges from a diameter of 24 mm. at its base to 39 mm. at a point 135 mm. farther up. The location of the siphuncle is central. The sutures of the septa slope downward toward the supposed ventral side in a manner similar to the preceding specimen. The surface of the shell is vertically ribbed in a manner similar to the cast of the interior in the preceding specimen. The number of these ribs is estimated at about 50 within the circumference of the conch, and they appear to be not appreciably more prominent than the ribs on the cast of the interior.

In a third specimen, approximately 150 mm. long, only the dorsal side of the conch is preserved. The vertical ribs on the surface of this fragment are about as frequent as in the preceding specimens but they are slightly more prominent. Six segments of the siphuncle are exposed in a length of 61 mm. It is not known how close their vertical axis passes to the center of the siphuncle, but in their present condition of exposure they attain a maximum width of 10.5 mm., contracting to 5 mm. at the septal necks. The latter are slightly over 1 mm. long. The general outline of these segments is elongated vertically, like a foot-ball, rather than spherical. The interior of the siphuncle is coated with calcarerous deposits which are thinner at the septal necks than along the connecting rings. Moreover, they are thicker along the lower segments of this siphuncle than farther up.

Locality and Horizon.—The first specimen here described was found at the coral reef in the river bank at Rowena, on the Cumberland River, in south-central Kentucky. The second was found at the coral reef opposite Belk Island, near Rowena. The third was found on the north side of Big Bend on the Cumberland River, about 2 miles above the mouth of Wolff creek. All are in the collection of Prof. W. H. Shideler at Miami University.

Cincinnati specimens.—Conch slowly enlarging, apical angle about 3.5 degrees. Specimens strongly flattened by pressure, location of siphuncle central. In one specimen, with a maximum diameter of 47 mm., the number of camerae in a corresponding length is 8. In another specimen, with a maximum diameter of 51 mm., the number of camerae in a corresponding length is 9, increasing to 11 just before reaching the living chamber. The sutures of the septa are directly transverse. The concavity of the septa in the specimen 45 mm. in diameter is 9 mm., and the maximum diameter of the siphuncle at this point is 10 mm., contracting to 4 mm. at the septal necks, the segments being nummuloidal in form. The number of strong vertical ridges in the specimen 45 mm. in diameter is about 37; the corresponding number in the specimen 60 mm. wide is estimated as between 40 and 44, depending upon whether some of the fairly strong intermediate striae are to be included in this count, or not. One specimen preserves the surface ornamentation distinctly. In this specimen the stronger vertical ridges are not acute, but strongly rounded, like thick cords. Between these primary vertical ribs there are single intermediate alternating ribs. In one of the interspaces between two of the primary ribs there are 4 secondary raised lines, but this is not true of any of the other interspaces. Both the ribs and the interspaces are ornamented by very fine vertical striae of which 9 to 11 occur in a width of 1 mm. No distinct transverse lines are present. Specimens numbered 48295 in the U. S. National Museum; from Covington, Kentucky, opposite Cincinnati, Ohio, in the Fairmount member of the Maysville formation. This formation lies directly beneath the Richmond, and is underlaid by the Eden formation, the three formations forming the Cincinnatian division at the top of the Ordovician.

20. **Beloitoceras arcticum** (Schuchert)

Plate VIII, figs. 6 A, B; pl. XXIII, fig. 5

Oncoceras arcticum Schuchert, Proc. U. S. National Museum, 22, 172, pl. 14, figs. 4–7 (1900).

Conch rapidly enlarging dorso-ventrally, especially along the phragmacone; strongly curved lengthwise, especially along its ventral outline, which is strongly convex, the dorsal vertical outline being concave, even along the living chamber. Living chamber contracted laterally toward the aperture. The sutures of the septa are nearly straight, curving downward only faintly along the lateral sides, but rising strongly from the dorsal toward the ventral side of the conch on approaching the living chamber. Siphuncle either in contact, or almost in contact, with the ventral wall of the conch along the more bulging part of its fusiform segments, but free at the ends of these segments.

Locality and Horizon.—From the head of Frobisher Bay, on Baffin Land; in strata regarded as of Trenton age; possibly including also Richmond strata. Specimen No. 28196, in the U. S. National Museum.

21. **Beloitoceras** (?) **cornulum** (Schuchert)

Plate VIII, figs. 8 A, B; pl. XXIII, fig. 7

Cyrtoceras cornulum Schuchert, Proc. U. S. National Museum, 170, pl. 14, figs. 8–10 (1900).

This specimen consists of part of the phragmacone which is characterized by its rapid lengthwise curvature as it approached the living chamber. The sutures of the septa curve slightly downward laterally, and rise ventrally, especially along the more strongly curved part of the conch. The siphuncle is about 0.2 mm. distant from the ventral wall of the conch at its lower end. Its segments are narrowly fusiform in outline.

Locality and Horizon.—From the head of Frobisher Bay, on Baffin Land; in strata regarded as of Trenton age, but possibly including also Richmond strata. Specimen No. 28121, in the U. S. National Museum.

Remarks.—The generic relationship of this specimen cannot be determined until the living chamber is known.

According to Schuchert "*Cyrtoceras cornulum* was first thought to be the young stage of *Oncoceras arcticum*, but its section is more elongate-oval, with the dorsal side more rounded, the reverse

being true in the latter species. The chambers also are deeper on the ventral side, the ventral curvature is less strong, and the shell thicker, with longitudinal plications." These longitudinal plications characterize casts of the interior of the conch, and are due to the gradual forward shifting of the animal at successive stages of growth of the shell. Along the attachment area the muscular structure of the animal appears to have been banded vertically. This vertical banding is one of the commonest features of the interior of cyrtoceroid conchs. Its prominence varies greatly in different individuals of the same species. Usually it is not accompanied by conspicuous banding on the exterior of the shell; or, if present exteriorly, the vertical banding usually is very faint.

22. **Beloitoceras** (?) **baffinense** (Schuchert)

Plate VIII, fig. 1; pl. XXIII, fig. 3. A, B

Cyrtoceras baffinensis Schuchert, Proc. U. S. National Museum, 22, 171, pl. 14, figs. 11–13 (1900).

Conch slightly curved lengthwise, the ventral outline being convex and the dorsal one concave; laterally compressed. The sutures of the septa curve slightly downward laterally, and ventrally they rise slightly above their level dorsally. The siphuncle is small and narrowly fusiform. Where the dorso-ventral diameter of the conch is 4.2 mm., the segments of the siphuncle are 0.25 mm. wide and 0.75 mm. distant from the ventral wall of the conch.

Locality and Horizon.—From the head of Frobisher Bay, on Baffin Land; in strata regarded as Trenton; possibly including also Richmond strata. Specimen No. 28198, in the U. S. National Museum.

Remarks.—According to Schuchert "This small species of Cyrtoceras has the general aspect of *C. manitobense*, and for a time regarded as the young of that species, yet a comparison shows that *C. baffinensis* has a somewhat smaller apical angle. The diagnostic feature, however, is in the depth of the air chambers. These are much more shallow and do not increase in depth with growth nearly as rapidly as in *C. manitobense*, there being twenty-

two of these in 25 mm., while in the latter species at a similar stage of growth there are about sixteen."

23. **Plectoceras undatum** (Conrad)

Plate XV, figs. 1 A, B, 2; pl. XVI, fig. 1; pl. XXVI, figs. 3, 4

Inachus undatus (pars) (Conrad MS.) Emmons, Nat. Hist. New York, Geol. 2, 394, fig. 104.

Lituites undatus Hall (pars), Pal. New York, 1, 52, pl. 13, fig. 1; pl. 13 bis. fig. 1 (1847).

Type specimen.—The specimen consists of about two and one third volutions. Its maximum diameter across the umbilical area is 116 mm. A break across the specimen at about 30 mm. from its larger end appears to locate one of the septa, and the entire specimen is assumed to belong to the phragmacone although no definite structure belonging to the interior of the conch is exposed. The earlier volutions may be in contact with each other, but toward the larger end of this specimen the volutions appear to be about 1 mm. distant from each other. There is a tendency toward oblique transverse rib-like folding along the lateral sides of the surface of the conch, especially along their ventral half. These folds reach their maximum prominence at the ventro-lateral shoulders, but nowhere are they as prominent as in the other species of *Plectoceras* considered here. Parallel to the folds there are oblique striae which occur both on the folds and on the intermediate spaces. At the apical end of the conch only the striae are present. Tendency toward rib-like folding makes its appearance where the dorso-ventral diameter of the conch attains a dimension of 13 mm. Beyond this point the rib-like folding gradually becomes accentuated. Counting downward from a point where the dorso-ventral diameter is 36 mm., about 4 folds occur in a corresponding length, measured along the ventro-lateral shoulders.

Where the dorso-ventral diameter of the conch is 40 mm., the lateral diameter is the same. The lateral sides are most prominent along their middle line; the ventral side is distinctly, though gently, convex; and the ventrolateral shoulders are rounded, the angulation here being slight, rather than abrupt.

This type specimen is numbered 829–1 in the American Museum of Natural History, and it is the original of Hall's figure 1 on plate 13 cited above.

The second specimen figured by Hall occupies all of his plate 13 bis. Its maximum diameter across the umbilical area is 160 mm., and it consists of at least 2.5 volutions. The cast of the interior of the living chamber is preserved for a length of 105 mm., measured along its axis, but the dorsal part of the chamber is retained for a distance of 15 mm. farther, and the entire length of the living chamber probably equalled about one-third of a volution. At earlier stages of growth the volutions probably were in contact with each other, but along the living chamber and along the adjacent part of the phragmacone the volutions probably were closely contiguous, but not in actual contact. Where the ventral side of the shell is preserved best, the dorso-ventral diameter is 38 mm., and the lateral diameter is estimated at about the same. The lateral sides round into the ventral side, along the ventro-lateral shoulders, with small angulation. The ventral side is distinctly, though gently, rounded. Four and a half folds occur in a length equal to the dorso-ventral diameter, measured along the ventro-lateral angles. Compared with the folds of other species of *Plectoceras*, those of the specimen described here are low and obscure, as though produced by the fasciation of the more prominent transverse striae.

Along the living chamber the shell varies in thickness from 2 mm. near the dorsal suture to 3 mm. at the ventro-lateral shoulders, diminishing again toward the median parts of the ventral side. About 4.5 camerae, measured along their ventral sides, occur in a length equal to the dorso-ventral diameter at the point under investigation. The sutures of the septa have distinct lateral and ventral lobes and low ventral saddles. Along earlier parts of the cast of the interior, faint traces of oblique transverse rib-like folds may be detected.

Locality and Horizon.—Watertown, New York; in the Black River limestone. The type specimen, numbered 829–1, is the original of Hall's figure 1 on plate 13, cited above. The second specimen, numbered 609–A, occupies plate 13-bis of the same pub-

lication. Both specimens are preserved in the American Museum of Natural History.

24. **Plectoceras halli** (Foord)

Plate XXI, fig. 3 A, B; pl. XXVI, figs. 5, 6.

Lituites undatus (part) Hall, Pal. New York, 1, 52, pl. 13, figs. 1a, 1b, 3 (1847) (not fig. 1 on plate 13, nor fig. 1 on plate 13-bis).

Cryptoceras undatum Chapman, Canadian Journ., n. s. 2, 267, (1857).

Trochoceras halli Foord, Cat. Foss. Ceph. British Museum, pt. 2, 42, text figs. 4a, 4b (1891).

Plectoceras halli Whiteaves, Pal. Foss., Geol. Surv. Canada, 3, pt. 4, 302, pl. 35, figs. 3, 4, 4a (1906).

Plectoceras obscurum Hyatt, Proc. Amer. Phil. Soc., 32, 445 (1894).

Original description.—

> The shell, which is not complete, consists of two volutions; the asymmetry is slight, but quite discernible. The shell increases its diameter about three times in the last volution. The section is distinctly subquadrate, the ventral side being the broadest, as well as being considerably flattened. The surface is ornamented with oblique, rounded, not very prominent annulations, divided by concave interspaces of about equal width. The annulations bend backwards on the ventral side, and there form a deep sinus; while on the dorsal or concave side, approaching the umbilicus, they become quite obsolete; the young shell is almost smooth. The entire surface of the test is covered with very fine transverse lines both on the ribs and the interspaces, and there are also obscure traces of longitudinal lines. The septa are a little more than 1 line apart, where the shell has a ventro-dorsal diameter of 6 lines. The siphuncle is not seen.

Locality and Horizon.—Lorette, 7 miles west of Quebec, Canada; in the Black River formation.

Whiteaves stated that adult specimens of *Plectoceras halli* average about three and a quarter inches or 83 mm. in their greatest diameter. The volutions always are closely coiled but may be either slightly separated throughout or partly in contact and partly free, but closely contiguous. The oblique rib-like folds are most prominent in the ventral and ventro-lateral region, but in some large specimens from Lorette they are more or less obsolete along the median part of the ventral side. The

sutures of the septa are nearly straight, and the siphuncle is cylindrical, ventral, and marginal.

New York specimens.—In the Paleontology of New York, vol. 1, 1847, Hall figured 4 specimens under the name *Lituites undatus*. Among these it has been possible to discriminate 2 species: *Plectoceras undatum* (represented by figure 1 on plate 13 and figure 1 on plate 13-bis) and *Plectoceras halli* (represented by figures 1a, 1b, and 3 on plate 13). The smaller of the two specimens of *Plectoceras halli* figured by Hall consists of about two and a quarter volutions and has a maximum diameter of 60 mm. across the umbilical area. At the larger end of the conch its lateral diameter is estimated at 25 mm., and its dorso-ventral one is 22 mm. The cross-section of the conch at this point is subquadrangular, this outline resulting chiefly from the very distinct flattening of the ventral side of the shell for a width of about 15 mm., and a corresponding flattening of its dorsal side for a width of 8 or 9 mm. Half a volution back from the larger end of the shell the ventral side of the conch is very faintly convex, but at the larger end of the conch it is very faintly concave, this appearance being due chiefly to the elevated humps present where the transverse oblique rib-like folds cross the ventro-lateral shoulders of the shell. At the larger end of the conch, the volu ions appear separate but closely contiguous; farther back they are in contact. The dorsal side of the volutions is flattened; toward the apical end of the conch it may have been impressed, but there is no evidence of impression visible. Absence of actual contact is suggested by the distinct preservation of the transverse striae along the ventral side of the earlier volution, as far as exposed. The lateral sides are most strongly convex along their middle, or slightly ventrad of their middle. They are ornamented by oblique, transverse, rib-like folds which disappear before reaching the dorsal suture, but which increase in prominence in the opposite direction, attaining their maximum prominence where crossing the ventro-lateral shoulders of the volutions, beyond which they rapidly diminish in prominence, becoming faint or almost obsolete before reaching the median parts of the ventral side. About 5 rib-like folds occur in a length of 34 mm. measured along the shoulders of the conch at its larger

end. From the dorsal suture the folds curve strongly backward, toward the apical end of the conch, as far as the point where they cross the ventro-lateral shoulders, a distance of 21 mm., and then they curve back still more strongly for a distance of 9 mm. to the point where they cross the median line of the ventral side of the shell, their total backward curvature equalling 30 mm. These rib-like folds evidently indicate successive stages of growth of the shell, its aperature being characterized by a deep hyponomic sinus. The sutures of the septa have shallow lateral and ventral lobes and low ventro-lateral saddles. The dorso-ventral curvature of the septum at the larger end of the specimen has a radius of 17 mm.; its lateral curvature is about the same. The siphuncle is 2.5 mm. in diameter and is located scarcely 1 mm. from the ventral wall of the conch. Its general form is cylindrical, not enlarging within the camerae. The shell is relatively thick. In addition to the rib-like folds, it is crossed by transverse striae, parallel to the latter.

The larger of the two specimens figured by Hall is weathered so as to expose a natural section passing chiefly parallel to the plane of symmetry, but along part of its margin it exposes also the strongly flattened or slightly concave ventral side of the conch. This side presents evidence not only of the oblique transverse rib-like folds and of the striae parallel to the latter, but also of longitudinal striae, very fine and numerous, about 8 to 10 in a width of 1 mm., more or less crinkled laterally, where they pass over the much coarser transverse striae. It is possible that these longitudinal striae are confined to one or more of the inner layers of the shell, and do not appear on its surface. Where the dorso-ventral diameter of the larger volution is 30 mm., the diameter of the siphuncle is 3 mm., and its distance from the ventral wall of the conch is 1 mm. Immediately above this level, 4 septa are fairly well outlined, and indicate that the included 3 camerae occupy a length of 30 mm. when measured along the ventral side. Below this level only the ventral ends of the septa are preserved. These may be detected as low as the point where the dorso-ventral diameter of the conch is only 16 mm. Within the length here indicated, 3 camerae occur in a length equal to the dorso-ventral

diameter of the conch at the top of the series counted, when this counting is done along their ventral side.

The smaller specimen figured by Hall is numbered 12581–2 in the New York State Museum, at Albany. The larger specimen is numbered 609B in the American Museum of Natural History, in New York city. Both were obtained at Watertown, New York, in the Black River.

In the Greene Museum at Milwaukee-Downer College, at Milwaukee, Wisconsin, there is a specimen of *Plectoceras halli* which has a diameter of 73 mm. across its umbilical area. At its larger end its dorso-ventral diameter is 27 mm., and its lateral one is 28 mm. The maximum convexity of its lateral sides is distinctly ventrad of their middle. The ventral side is strongly flattened, varying between faintly convex and faintly concave. The concave appearance being produced by the rib-like folds which were prominent at the ventro-lateral shoulders of the conch. These folds retain their prominence for some distance from the ventro-lateral shoulders on entering the flattened ventral surface of the shell. The hyponomic sinus apparently was deeper and more angular, at successive stages of growth of the conch, than in the specimens figured by Hall. At the base of the living chamber the dorso-ventral diameter is 23 mm., and the camera immediately beneath is only 3 mm. long. The shortness of this camera suggests that the conch had reached maturity. Apparently *Plectoceras halli* is a much smaller species than *Plectoceras undatum*. At the larger end of the Greene Museum specimen the thickness of the shell at the ventro-lateral shoulders was fully 1 mm.

25. **Plectoceras occidentale** (Hall)

Plate III, fig. 1; pl. XVII, fig. 1; pl. XXVI, fig. 1

Lituites undatus occidentalis Hall, Rept. Superintendent Geol. Surv. Wisconsin, 1861, p. 38; also Whitfield, Mem. Amer. Mus. Nat. Hist., 1, pt. 2, 63, pl. 10, fig. 7; pl. 11, fig. 1; pl. 12, fig. 3 (1895).

Type specimen.—The conch consists of at least 3 volutions. The maximum diameter across the umbilical area is 195 mm.

The dorso-ventral diameter near the aperture of the living chamber is 58 mm., and the maximum lateral diameter at the same point is 56 mm. Apparently the earlier volutions are in contact with each other, and the dorsal side of one volution may be impressed by the ventral side of the preceding volution, but, 30 mm. from the aperture, the living chamber becomes free, and at the aperture it is 10 mm. distant from the preceding volution. The ventral side of the conch is abruptly and strongly flattened across a width equal to three-fifths of the lateral diameter of the conch. There are indications on the surface of the specimen of the oblique transverse rib-like folds and of the transverse striae which are parallel to these folds. There also are traces of some of the septa, but these features are better exposed on the Homer specimen, described next. The thickness of the shell is remarkable. Along the ventro-lateral shoulder of the living chamber it equals 6 mm., diminishing to 5 and 4 mm. toward the middle of the lateral sides, and to 3 mm. near the dorsal sutures and along the ventral side.

Locality and Horizon.—Beloit, Wisconsin; from the Platteville member of the Black River. Numbered 1002–1 in the American Museum of Natural History. Represented by figure 7 on plate 10 of the publication by Whitfield, cited above.

Homer specimen.—The conch consists of 3 volutions. The living chamber occupies a length of 150 mm., measured along its central axis, which is equivalent to about one-third of the length of one volution. The maximum diameter across the umbilical area is 198 mm. The maximum lateral diameter of the living chamber at its aperture is 59 mm., and the dorso-ventral one is 57 mm. One volution back from the aperture, the lateral diameter of the conch is 36 mm., and the dorso-ventral one is 37 mm. The earlier volutions probably are in contact with each other, and possibly the dorsal side of one volution is faintly impressed by the ventral side of the preceding volution, but nearer the larger end of the phragmacone the volutions probably become free, and at the aperture the living chamber is 4 mm. distant from the preceding volution.

Near the upper end of the phragmacone 5.5 camerae occupy a

length, when measured along the central axis of the conch, which is equal to the dorso-ventral diameter of the conch at the point under investigation. The last 6 camerae shorten consecutively from a length of 11 mm. to one of 8 mm. on approaching the base of the living chamber, thus suggesting that the conch had reached maturity. The sutures of the septa have lateral lobes with a depth of about 6 mm., and also a ventral lobe which is separated from the lateral lobes by low ventro-lateral saddles.

The shell is crossed transversely by oblique rib-like folds, of which 7 occur in a length of 7.5 camerae, the distance between the folds being greater than that between the septa. These folds are strongly defined only where they cross the ventro-lateral angles, and thence for a relatively short distance along the lateral sides. They tend to become obsolete along the dorsal half of the lateral sides and along the greater part of the width of the flattened ventral side, but their general direction is continued by the transverse striae which are parallel to the folds, and which are present both on the folds and on the parts intermediate to the folds. From the dorsal suture halfway across the lateral sides of the conch the folds and striae curve only moderately backward, but along the ventral half of the lateral sides the rate of backward curvature increases, until at the ventro-lateral shoulders the folds are the length of 4 camerae beneath their level at the dorsal sutures. From the ventro-lateral shoulders to the point where the folds cross the median line of the ventral side of the conch, there is a further descent of almost 2 camerae. Traces of rib-like folding are present even near the apical end of the conch. Along the most prominent part of the folds the thickness of the shell reaches 4 mm., alternating with thicknesses of less than 3 mm. in the spaces between the folds. Toward the dorsal third of the lateral sides of the shell its thickness equals 2 mm., and along the median parts of its lateral and ventral sides its thickness is less than 2 mm.

This second specimen is from Homer, in Troy Grove township, is LaSalle county, Illinois. It is numbered 1002–5 in the American Museum of Natural History, and is the original of fig. 1 on plate 11, and also of fig. 3 on plate 12 of the publication by Whitfield, cited above.

Remarks.—The strong, abrupt flattening of the ventral side of the conch distinguishes *Plectoceras occidentale* readily from *Plectoceras undatum*. From *Plectoceras halli* this species differs chiefly in its much greater size. Moreover, the maximum elevation of its lateral sides is along the median part of these sides, rather than distinctly ventrad of the latter.

26. **Plectoceras lowi** Sp. nov.

Plate XVIII, fig. 1; pl. XIX, fig. 1; pl. XXVI, fig. 2

Volutions of conch apparently in contact with each other, but without a dorsal impressed zone along the area of contact. Consisting of about three and a half volutions, of which the living chamber probably occupied a length of about one-third of a volution, though the actual length of the part here preserved equals only 145 mm., the maximum diameter of the conch across its umbilical part being 230 mm. One side of the specimen exposes chiefly its exterior, strongly incrusted with deposits of lime; the other side is strongly weathered and exposes the septa and parts of the siphuncle.

At the larger end of the specimen its dorso-ventral diameter is estimated at 60 mm. One volution back from this larger end, the dorso-ventral diameter is 44 mm. and the lateral one is about the same, or possibly 1 or 2 mm. less. The earlier volutions of the conch probably are in contact with each other, and the dorsal side may be slightly impressed, but toward the aperture the living chamber is not in actual contact with the preceding volution, though closely contiguous. The maximum prominence of the lateral sides is along their middle. The ventral side is distinctly, though gently convex. The ventro-lateral angles are broadly rounded, so as to present only a moderate degree of angularity between the lateral and ventral sides. Where the lateral diameter of the conch is 42 mm., the area of contact with the preceding volution is estimated to have a width of 18 mm., but the presence of an impressed zone here can be determined only by sectioning the specimen. At younger stages of growth the cross-sections of the volutions appear to have been nearly

circular. At maturer stages the slight ventral flattening appears to have been accompanied by a corresponding slight lateral flattening.

At the beginning of the last volution of the phragmacone about 3 camerae occupy a length equal to the dorso-ventral diameter at this point. At the larger end of the phragmacone nearly 4 camerae occupy a corresponding length. The sutures of the septa have very shallow ventral and lateral lobes and low ventro-lateral saddles. The ventral lobes have a maximum depression of about 3 mm., while the depression of the lateral lobes does not exceed 2 mm. Possibly the depth of the ventral lobes has been accentuated by lateral compression of the conch. Most of the curvature of the lateral lobes appears to take place on approaching the dorsal sutures. The septa have a radius of curvature of 35 to 40 mm. in a dorso-ventral direction at the larger end of the phragmacone. The ventral lobes are due in part to flattening of the ventral side of the volutions.

The siphuncle is exogastric, and in the last volution of the phragmacone its center is located one-sixth of the dorso-ventral diameter from the ventral wall of the conch. The diameter of the siphuncle equals almost one-sixth of the dorso-ventral diameter of the conch. The structure of the siphuncle is indicated only obscurely. The septal funnels are at least 2 mm. long. Successive funnels are connected by cylindrical segments of the siphuncle whose lower margin invaginates into the top of the funnel beneath. It cannot be determined whether there is a cylindrical ring distinct from the septal funnels.

The shell probably was about 2 mm. thick along the lateral sides of the upper part of the phragmacone. It may have been thicker along its ventro-lateral sides, and thinner along the median part of its ventral side. The surface of the shell is crossed obliquely by transverse rib-like folds, which curved backward along the lateral sides of the conch for a distance slightly exceeding the length of 3 camerae, and along the ventral side for an additional distance of almost 2 camerae, thus totalling about 5 camerae. The hyponomic sinus evidently was rather narrowly V-shaped. At the larger end of the phragmacone four of the folds

occupy a length equal to a little over 6 camerae, when measured along the ventro-lateral side of the conch. The folds are distinctly defined along these ventro-lateral sides and along the ventral half of the lateral sides of the conch. They become weak or nearly obsolete toward the dorsal sutures and toward the median parts of the ventral side. No trace of these folds is seen on casts of the interior of the conch. In addition to these oblique rib-like folds the surface of the conch probably was crossed by transverse striae, parallel to the folds, but the incrustation of its surface by lime prevents the recognition of the finer surface markings.

Locality and Horizon.—Found at Port Burwell, a few miles west of Cape Chidley, at the northern end of Labrador, at the eastern end of Hudson Strait; in loose boulders, apparently of Black River age. Collected by A. P. Low in 1904, and numbered 7929 in the collections of the Geological Survey of Canada, in the Victoria Memorial Museum.

Remarks.—The specimen described here from Cape Chidley evidently is closely related to *Plectoceras undatum*. It has about the same degree of convexity along its lateral and ventral sides, and the same rounding of the ventro-lateral shoulders. It differs chiefly in having the rib-like oblique folds more sharply defined toward the ventro-lateral shoulders, and more distantly spaced along the conch. The lateral lobes of the sutures are more shallow. Moreover, the Cape Chidley specimen is larger than the largest specimen of *Plectoceras undatum* so far known.

27. **Eurystomites kelloggi** (Whitfield)

Plate XVI, fig. 2; pl. XXVII, fig. 1.

Nautilus kelloggi Whitfield (part), Bull. Amer. Mus. Nat. Hist., 1, 328, pl. 30, fig. 1 (1886) (not pl. 31, figs. 4, 5, which belong to *Eurystomites rotundus* Hyatt).

Eurystomites kelloggi Hyatt, Amer. Phil. Soc. Proc., 32, 442, pl. 5, figs. 4, 5 (1894); also Ruedemann, Bull. New York State Mus., 90, 456, text figs. 21, 22; pl. 17, fig. 1; pl. 18, fig. 1 (1906).

Maximum diameter of conch across the umbilical area 156 mm.

That part of phragmacone which is one-fourth of a volution back from the base of the living chamber has its ventral side broken off. There are 3.5 volutions, the living chamber occupying slightly more than one-third of the last volution. At the aperture of this chamber the dorso-ventral diameter of the conch is 52 mm., the lateral diameter being 45 mm. That part of the dorsal side of this chamber which is in contact with the preceding volution is 24 mm. wide. The depth to which the dorsal side of the chamber is impressed at the aperture cannot be determined accurately, but is estimated at 2 mm. The maximum lateral diameter of the conch is about one-third of its dorso-ventral diameter from its dorsal side. From this point, the transverse curvature of the conch is rapid toward the dorsal side, but toward the ventral side it is more moderate until the ventro-lateral angles are reached, where the transverse curvature is distinctly more rapid. The sides of the conch converge moderately in a ventrad direction as far as these ventro-lateral angles. The transverse curvature of the ventral side is moderate, but greater than that of the lateral sides. Four camerae occupy a length equal to the dorso-ventral diameter of the conch near the top of the phragmacone. The sutures of the septa have broad lateral lobes and broad dorsal and ventral saddles. At the top of the phragmacone the depth of the lateral lobes equals nearly 4 mm. Half a volution farther back their depth equals about 1.5 mm. Near the aperture the ventral saddles of the preceding volution have a very faint and broad depression or lobe medially. The siphuncle is not exposed distinctly but cannot have been closer than 5 mm. to the ventral wall of the conch at the base of the fifth camera from the base of the living chamber. On the surface of the shell there are traces of transverse undulations, parallel to the transverse striations. These undulations are obscure laterally, but fairly distinct ventro-laterally. In fact, they are about as distinct as the transverse plications of *Plectoceras undatum*, which are equally poorly defined.

Locality and Horizon.—Fort Cassin, Vermont; in the Fort Cassin member of the Beekmantown, regarded as of Upper Canadian age. Specimen no. 490, in the American Museum of

Natural History; the original of pl. 30, fig. 1, published by Whitfield, and cited above.

28. **Eurystomites chidleyense** Sp. nov.

Plate II, fig. 2 A, B, C; pl. XX, fig. 1; pl. XXVII, fig. 2 A–F

Nautilicone discoidal, the phragmacone consisting of about 3 volutions. The maximum diameter of that part of the phragmacone which is at hand is 155 mm. The complete shell probably attained a diameter of at least 185 mm. At the larger end of the phragmacone the dorso-ventral diameter of the cross-section is 47 mm., and the lateral diameter is estimated at 52 mm. Half a volution back from this larger end, the lateral diameter of the phragmacone is 42 mm. From this it is estimated that the lateral diameter at the aperture of the conch probably was about 65 mm.

Volutions quadrangular in cross-section, with the venter broader than the dorsum. The ventral side is distinctly flattened, appearing gently convex in cross-section. The ventro-lateral angles are rather abruptly rounded, especially at later stages of growth in which there is a tendency toward flattening of the lateral sides. The transverse curvature of the lateral sides is greatest on approaching the ventral side of the volutions. The dorsal side is gently, but broadly, impressed, owing to close contact with the preceding volution. Where the lateral diameter of the phragmacone is 52 mm., the area of contact with the preceding volution is about 26 to 28 mm. in width, and the degree of concavity of the dorsal impressed zone is estimated at 1.5 mm.

At younger stages of growth the volutions are more depressed dorso-ventrally than at later stages. The ratio of the dorso-ventral to the lateral diameter increases from 75 per cent along the second volution to 85 and 90 per cent toward the end of the third volution. At the same time the dorsal side of the volutions becomes relatively broader, the area of contact between successive volutions widens, the lateral sides are more distinctly flattened and converge less strongly dorsally, the cross-section of the volutions becoming more quadrangular.

Along the second volution and the earlier half of the third volution 3 camerae occupy a length equal to the width of the volution at the point under investigation, but along the last half of the third volution 4 camerae occupy a corresponding length, indicating approach to maturity.

The sutures of the septa have ventral, lateral, and dorsal lobes, separated by ventro-lateral and dorso-lateral saddles. Toward the larger end of the phragmacone the ventral lobes have a concavity of 6 or 7 mm., the lateral lobes having a concavity of 5 mm., and the dorsal lobes one of 5 or 6 mm. Owing to the narrowness of the dorsal side of the volutions, the dorsal lobes and dorso-lateral saddles are more strongly curved than the ventral lobes and ventro-lateral saddles. The depth of the lateral lobes is due chiefly to the strong forward curvature of the sutures on approaching the dorso-lateral angles of the volutions. The septa have a radius of curvature of about 35 mm., and the lobes and saddles of the sutures result chiefly from the quadrangular cross-section of the volutions.

The siphuncle is exogastric, and its center is located about a fifth or a sixth of the length of the dorso-ventral diameter from the ventral side of the conch, being relatively nearer at later stages of growth. The diameter of the siphuncle equals about one-sixth of the dorso-ventral diameter of the phragmacone at the point under investigation. The septal funnels apparently are only about 2 mm. in length at the larger end of the phragmacone. Successive funnels are connected by tubular segments of the siphuncle whose lower margins are inserted into the tops of the funnels beneath.

The shell has a thickness of about one millimeter. Only a few traces of its surface are preserved. The surface ornamentation consists of transverse striae. These curve strongly backward from the dorso-lateral angles as far as the median part of the ventral side where they indicate the former presence of a hyponomic sinus more than twice as deep as the ventral lobe of the suture of the septum at the same point. Along the ventro-lateral angles there are traces of oblique rib-like folds, parallel

to the transverse striae. Along various parts of the last volution of the phragmacone five of these folds occur in a length of 7 camerae. There is no distinct continuation of these oblique folds along the lateral or ventral sides of the volutions at any distance from their ventro-lateral angles.

Locality and Horizon.—From Port Burwell, several miles west of Cape Chidley, at the northern end of Labrador, at the eastern end of Hudson Strait; found loose in erratic blocks of limestone regarded as of Black River or Trenton age. Collected by A. P. Low in 1904, and numbered 7932 in the collections of the Geological Survey of Canada, in the Victoria Memorial Museum.

29. **Ophidioceras** (?) sp. (Cornwallis Island)

Lituites n. sp.-Salter, in Sutherland's Voyage to Baffin's Bay and Barrow's Straits, 2, ccxxii (1852).

The following is the description published by Salter:

> Quite discoid, and the general form flat. Whorls, in a shell one inch and three-quarters broad, six or seven at least, only just touching each other, compressed and bluntly keeled on the back. Their sides very convex and ribbed across from the inner margin nearly to the keel. The ribs are prominent, a little curved backwards.
>
> This pretty shell much resembles *L. articulatus* Sow. (Silur. Syst., t. 11, f. 7.); but the number of whorls is much greater, the sides are more convex, and the back not so sharp. We regret that want of space has obliged us to omit a figure of it.
>
> Locality.—Cornwallis Island; Mr. Pickthorne.

Remarks.—*Lituites articulatus* Sowerby[26] included two species, of which *Ophidioceras articulatum* is illustrated by his figure 5, while a cyrtoceroid later described by Blake as *Cyrtoceras extricatum* was the basis of his figure 7. Evidently it was the coiled species, *Ophidioceras articulatum*, with which the arctic species was compared by Salter. It is needless to remark that only a direct examination of the specimen described by Salter will serve to determine its generic relationship, which may not be that of *Ophidioceras*.

[26] R. I. Murchison. Silurian System, pt. 2, 622, pl. 11, fig. 5 (not fig. 7) (1839).

30. **Charactoceras schucherti** Sp. nov.

Plate IX, figs. 2 A, B, C; pl. XXVII, fig. 4 A–D

Eurystomites plicatus (?) Schuchert, Proc. U. S. National Museum, 22, 173 (1900).

Specimen consisting of the basal part of the living chamber and of a little more than one volution of the phragmacone. Originally this specimen probably had a phragmacone more that 2 mm. in length, but its umbilical parts are not preserved. The maximum diameter of the phragmacone, across its umbilical area, is 77 mm. The conch enlarges dorso-ventrally in one volution from a diameter of 16 mm. at a point opposite the base of the living chamber to 30 mm. at the base itself, the axial length of this volution being about 120 mm. The corresponding lateral diameters are 25 mm and 47 mm. At a point 68 mm. from the base of the living chamber, measured along its longitudinal axis, the dorso-ventral diameter is 25.5 mm. and the lateral one is 34 mm. The conch evidently is distinctly depressed along the entire length of its last volution, but its earlier stages are unknown.

At the base of the living chamber, the ventral side of the conch is broadly rounded, its radius of transverse curvature being 40 mm. Along the ventro-lateral shoulders the radius of curvature is 13 mm., changing to 15 mm. between the ventro-lateral shoulders and the median dorsal impression formed at contact with the preceding volution. This dorsal impression is 20 mm. wide and has a concavity of 2 mm. From the ventro-lateral shoulders the lateral sides of the conch converge strongly toward its dorsal side. Near the top of the phragmacone the sutures of the septa have broad saddles extending the entire width of the ventral side and rising about the height of two camerae above the level of the sutures along the lateral side of the conch. Laterally there are shallow lobes about one camera in depth. Dorsally the sutures are nearly directly transverse, but deflect slightly downward within the impressed area. The same type of structure, though less pronounced, is shown 68 mm. beneath the living chamber.

At one volution back from this chamber, directly opposite its base, the ventral saddles and lateral lobes still may be detected, but both are only weakly defined.

At a point 68 mm. beneath the living chamber, where the dorso-ventral diameter is 25.5 mm., the center of the siphuncle is located almost 5 mm. from the ventral wall of the conch. One volution from this chamber, where the dorso-ventral diameter is 16 mm., the center of the siphuncle is 3.7 mm. from this wall. The diameter at the septal neck is 1 mm., enlarging to 1.4 mm. within the camerae. The enlargement of the segments takes place chiefly near the septa, the greater part of the length of the connecting rings being almost cylindrical. On the dorsal side of the siphuncle the septal neck is very short, curving rapidly downward for a distance of three-tenths of a millimeter. On its ventral side, the downward curvature of the septal neck is more moderate, equalling eight-tenths of a millimeter in length.

Only the cast of the interior of the conch is at hand. No surface markings of the shell are preserved.

Locality and Horizon.—From the head of Frobisher Bay, on Baffin Land; in strata regarded by Schuchert as of Trenton age. Specimen No. 28123, in the U. S. National Museum.

Remarks.—Conch closely related to *Charactoceras plicatus* Whiteaves,[27] with which it agrees in the small expansion of the siphuncle within the camerae. It differs from the latter in the much less rapid rate of expansion of the conch laterally.

Typical *Charactoceras plicatus* occurs in lower part of the Winnipeg limestone as exposed in the southern part of the Lake Winnepeg area. It contains a fauna closely similar to that identified by Troedsson as Richmond, in his Cape Calhoun series.

Another closely related species is *Charactoceras rotundum* Troedsson,[28] described from the Richmond part of the Cape Calhoun series.

[27] J. F. Whiteaves. Palaeozoic Fossils, Geological Survey of Canada, 3, pt. 3, 225, pl. 22, fig. 2, text figs. 15, 16 (1897).

[28] Gustaf T. Troedsson. On the Middle and Upper Ordovician Faunas of Northern Greenland, pt. 1, Cephalopods, 40, pl. 18, figs. 1–3 (1926).

31. **Actinoceras** sp. (Bering Strait)

Plate VII, fig. 3; pl. XXVIII, fig. 2

The interest in this specimen is due solely to its suggesting the Ordovician age of the strata in which it is found. It was secured from the American side of Bering Strait, presumably on Cape Prince of Wales. It is preserved in the collections of the U. S. National Museum.

By grinding off the matrix it was discovered that the segments of the siphuncle were apparently in contact with the ventral wall of the conch. The sutures of the septa apparently curved downward on this ventral side. The segments of the siphuncle are estimated to have been about 32 mm. in a lateral diameter, and about 26 mm. dorso-ventrally. Nothing definite could be learned regarding the structure of the septal necks, but the annular part of the segments of the siphuncle appears to occupy only the lower part of the camerae, leaving room for long septal necks, as in typical *Actinoceras*. Species of this type are not uncommon in the Black River and Trenton.

32. **Kochoceras lenticulare** Foerste

Plate XI, fig. 3; pl. XXV, fig. 1, A, B.

Kochoceras lenticulare Foerste, Jour. Sci. Labs. Denison Univ., 22, pl. 7, fig. 1 (1927).

Specimen 52 mm. long, consisting of the lower part of a siphuncle with the immediately adjacent parts of the shell and septa. This specimen includes 7 segments of the siphuncle. All of these are strongly depressed dorso-ventrally, their ventral side being distinctly flattened, especially medially. The second segment from the base is the largest, its lateral diameter being 29 mm., and its dorso-ventral one 18 mm. From this the siphuncle diminishes regularly in size to a width of 22 mm. and a dorso-ventral diameter of 12 mm. at the top of the specimen, in an interval of 32 mm. The lowest segment appears to have a width of 22 mm. and a dorso-ventral diameter of 16 mm., but its outlines are not delimited distinctly. Along the ventral side of the

siphuncle its transverse outline has a radius of convex curvature of about 25 mm. Along its dorsal side this radius is about 17 mm. The annulations formed by the segments extend fully 2 mm. beyond the intervening grooves along the dorsal and lateral sides of the siphuncle, but ventrally the annulations have disappeared almost entirely, only a slight groove remaining at the septal necks, between the flattened areas of contact where the ventral walls of the segments of the siphuncle are adnate to the ventral wall of the conch.

The segments of the siphuncle are nearly horizontal in direction, except toward the base of the specimen where they rise more or less from the ventral side of the siphuncle toward its dorsal side. The sutures of the septa curve distinctly downward on the ventral side of the conch. The lower faces of the annulations formed by the segments of the siphuncle are obliquely concave. The septa are adnate to these concave parts from the base of the segments upward, becoming free where the concave curvature of the vertical outline of the segments changes to convex. The endosiphonal passage through the central part of the siphuncle is located nearer the ventral side of the oblique base of the specimen, as viewed from one of its lateral sides.

Locality and Horizon.—This specimen is numbered C 2712 in the British Museum of Natural History. It bears the word *Polar* written in ink. It is listed as collected on the Expedition of the "Alert" and "Discovery," during the years 1875–76, from the Silurian of some unknown locality. It probably was obtained somewhere between Dobbin and Scoreby Bays on the east coast of Ellesmereland, since this was the only area in which Ordovician and Silurian fossils were collected by this expedition, aside from the lithologically very different Silurian fossils exposed on the northern side of Bessels Bay in northern Greenland.

Remarks.—*Kochoceras lenticulare* differs from *Kochoceras feildeni* in its much smaller size, in the far greater depression of the siphuncle dorso-ventrally, and in the relatively greater width of the areas of attachment of the segments of the latter to the ventral wall of the conch. Siphuncles of this type are known at present only from the Black River, Trenton, and Richmond.

33. **Kochoceras feildeni** Foerste

Plate XI, fig. 2 pl. XXV, fig. 2 A, B.

Kochoceras feildeni Foerste, Jour. Sci. Labs. Denison Univ., 22, pl. 10, fig. 1 A–C (1927).

Specimen 115 mm. long, strongly flattened ventrally and semicircular in cross-section dorsally, the ventro-lateral shoulders being rapidly rounded. At the base of the specimen its lateral diameter is 71 mm., and its dorsoventral diameter is estimated at 46 mm., judging from the transverse curvature of the dorso-lateral part of its outline. The transverse curvature of the dorsal side here has a radius of 35 mm., while that of the ventral side is 70 mm., and that of the ventro-lateral shoulders is 18 mm. The conch apparently enlarged fairly rapidly in a lateral direction, but the rate of this enlargement cannot be determined accurately, and the estimate that this apical angle equalled 16 degrees may have little value.

The specimen includes 7 segments of the siphuncle with more or less of the enclosing camerae, and in addition to this the upper half of an eighth segment is attached at its base. The total length occupied by the 7 segments differs considerably along their dorsal and ventral outlines, equalling 82 mm. along the former and 92 or 93 mm. along the latter. The length of the successive segments, measured along their dorsal side, in ascending order is 14, 12, 11.5, 11, 11, 12, and 11 mm.; measured along their ventral side it is 16, 13, 13.5, 13, 13, 12, and 12 mm. The result is that while the upper side of the lowest segment slopes downward from the dorsal toward the ventral side so as to form an upper angle of 80 degrees with the vertical ventral outline of the siphuncle, the upper side of the uppermost segment rises in this direction to an equal degree, so as to form an angle of 100 degrees with the vertical outline. Beginning with the upper part of the segment of the series of 7 here under consideration, the inclinations of the upper surfaces of the successive segments, in ascending order, are 80, 83, 86, 90, 94, 98 and 100 degrees. Along the dorsal side of the siphuncle 6.5 segments occupy a length equal to the lateral diameter of the conch at the base of the series under

investigation; along the ventral side 6 occur in a corresponding length.

The dorso-ventral diameter of the siphuncle, at the base of the specimen, is 40 mm. The lateral diameter was at least 43 mm. and may have been greater. From this it is estimated that about 4 segments occupied a length equal to the lateral diameter of the siphuncle.

Along the dorsal side of the specimen the sutures of the septa appear to have been approximately or directly transverse, but along the ventral side they curve strongly downward for a total distance of at least one camera, probably exceeding this amount slightly. The septa curve downward even more strongly, the depth of their curvature equalling or slightly exceeding 1.5 camerae.

The segments of the siphuncle are in contact with the ventral wall of the conch for at least four-fifths of their height, and probable for a lateral width of 25 mm. The areas of contact with the ventral wall of the conch therefore are relatively large and elliptical in outline.

The constrictions of the siphuncle at the septal funnels differ not only in their dimensions in a vertical direction but also in the distance to which they extend inward from the outer parts of the siphuncle, on passing from the dorsal to the ventral side. On the dorsal side the inner parts of these constrictions have a vertical height of 1.5 to 2.5 mm. between different segments. On the ventral side the walls of successive segments appear to be actually in contact. On the dorsal side, therefore, the septal necks have a length of about 2.5 to 3 mm., while on the ventral side their lower margin recurves so abruptly and so close to the septum itself that there is no septal neck in the usual sense of the term, and that which more nearly corresponds to a neck scarcely exceeds half a millimeter in length vertically. Along the dorsal side of the siphuncle the septum is adnate to the lower face of the segments along the concave part of their curvature, for a distance of 5 mm. from the innermost part of the constriction.

The interior of the siphuncle is partially filled with calcareous deposits, exhibiting a central space, filled with matrix, and also

showing the so-called tubuli. Where this central space is constricted to small dimensions it evidently is the so-called endosiphuncle. Toward the upper part of the specimen it enlarges into an elongate funnel-shaped space, and there is another space at the bottom of the specimen where for some unknown reason no calcareous deposits occur across that part of the segment of the siphuncle which here remains. The surface of the shell apparently was marked by transverse striae, from 6 to 9 in a length of 5 mm.

Locality and Horizon.—On the ventral side of this specimen occurred, at the time of its receipt, the words *C. Napoleon*, written in large letters in ink. These words were cut away almost entirely in cutting a vertical section through the center of the siphuncle in a dorso-ventral direction. Cape Louis Napoleon is located west of the center of Kane Basin, at 72° 15′ west longitude, and 79° 38′ north latitude. Apparently both Ordovician and Silurian strata are exposed in its vicinity, but the genus *Kochoceras* is known at present only in Black River, Trenton, and Richmond strata.

The specimen here described is numbered 89179 in the British Museum of Natural History, collected by Capt. H. W. Feilden, on the Expedition of the "Alert" and "Discovery" during the years 1875–1876. It is recorded in the Museum as *Actinoceras? backi* Stokes, sp.

34. **Kochoceras mantelli** Foerste

Plate XXV, fig. 4

Kochoceras mantelli Foerste, Jour. Sci. Labs. Denison Univ., 22, pl. 7, fig. 3 (1927).

Specimen 77 mm. long, consisting of the ventral half of 9 camerae. The vertical ventral outline of this fragment is straight, except toward its base where it curves in a convex direction. Along the third and second camerae from the base this lengthwise curvature is slight, but along the basal camera it becomes much greater. The basal camera apparently terminates in an obtuse point, on the dorsal side of which the siphuncle opens obliquely. The radius of curvature of the ventral outline along this basal camera is 10 mm.

At the top of the third camera from the base, the lateral diameter of the conch is 26 mm.; 50 mm. farther up its lateral diameter is estimated to have been 32 mm., thus indicating an apical angle of 7 degrees. Below the level of the third camera above the base of the specimen the conch contracts rapidly, the lateral diameter at the top of the second camera being 24 mm., and that at the top of the lowest camera being estimated at 18 mm.

Only the ventral and lateral parts of the conch are present, the dorsal side having weathered away. The ventral side is strongly flattened, at least in its present condition. Its convexity does not appear to have exceeded that having a radius of curvature of 25 mm.; and this radius may have been considerably greater. The transverse curvature of the lateral sides has a radius of curvature of 7 or 8 mm. Where the lateral diameter of the conch is 26 mm., the dorso-ventral one may have equalled 20 mm., judging from the transverse curvature of that part of the conch which is preserved, especially that part which forms its lateral sides.

The number of camerae in a length equal to the lateral diameter of the conch equals 4. The ventral side of the specimen is crossed by distinct but very shallow grooves which locate the sutures of the septa. These sutures curve distinctly downward on the ventral side for a distance equalling about two-thirds of the height of a camera. Along the lateral sides of the conch, however, these sutures become so nearly horizontal that it is very likely that their course across the dorsal side of the conch was directly transverse.

The siphuncle appears to have been nearly as wide as the conch. At the top of the third camera from the base of the specimen, where the lateral diameter of the conch is 26 mm., the lateral diameter of the siphuncle appears to equal 23 mm. At the top of the ninth camera the lateral diameter of the siphuncle is 22 mm. or slightly less.

The siphuncle is strongly depressed in a dorso-ventral direction. In its present condition the dorso-ventral diameter appears to be only about 11.5 mm., but this may be due partly to weathering, and originally this diameter may have equalled 13 mm. At the

top of the specimen, where the dorso-ventral diameter of the eighth segment from the base is 11 mm., the constriction immediately above is 9.5 mm. in diameter. Estimating the depth of the constriction at 3 mm., the dorso-ventral diameter of the annulation of the segment should be 12.5 mm. A vertical section through the siphuncle in a dorso-ventral direction, but 7 mm. toward the right of its center, shows that the annulations were more narrowly rounded on the dorsal than on the ventral side of the siphuncle. Apparently the septa rose from the ventral toward the dorsal side of the conch, including most of the dorso-ventral diameter of the siphuncle.

Along its ventral side the siphuncle is strongly flattened by contact with the ventral wall of the conch. The resulting contact areas are transversely elliptical or lenticular in outline. At the third camera from the base this area of contact is 23 mm. in width laterally; at the top of the specimen it does not appear to have exceeded 16 or 17 mm., judging from appearances along the exterior of the specimen.

Locality and Horizon.—From Igloolik Island, in Fox Channel, in Arctic America. Collected by Dr. G. A. Mantell in 1839, in strata recorded as Lower Silurian or Ordovician. Specimen No. 33563 in the British Museum of Natural History; listed there as *Actinoceras ? Bigsbyi.*

Remarks.—The structure of the apical end of this specimen evidently is comparable with that presented by figures 22 and 23 on page 165 of the Catalogue of Fossil Cephalopoda in the British Museum, published by Foord in 1888. Here figure 22–1 presents the apical end of an *Actinoceras* doubtfully referred to *Actinoceras Bigsbyi*, from the Black River formation of Igloolik Island, the same locality at which the specimen described above was obtained. Figures 22–2 and 23 represent a similar specimen from Great Slave Lake, in northern Canada belonging, however, to a distinct species.

Specimen 33563, here described, is regarded as a new species. It differs from *Kochoceras feildeni* in its much smaller size, and in the much greater depression of its siphuncle dorso-ventrally. It differs from *Kochoceras lenticulare* in a different angle between

the lateral sides of the siphuncle and the adjacent parts of the conch, and in having a more uniform length of the dorso-ventral diameter of the siphuncle between the top and bottom of the latter.

35. **Kochoceras foordi** Sp. nov.

Plate VI, fig. 3

Actinoceras bigsbyi Foord, Geol. Mag., dec. 3, vol. 5, 489, fig. 3 (1) (1888); also Cat. Foss. Cephalopoda British Museum, pt. 1, 165, fig. 22 (1) (1888).

Specimen 57 mm. long, enlarging laterally at an apical angle of about 13 degrees, from a lateral diameter of 38 mm. at its base. It is estimated that about 5.3 camerae occurred in a length equal to the lateral diameter of the conch at the top of the series counted. The sutures of the septa on the lateral side of the specimen slope downward in a ventrad direction. The specimen exposes at its base a septum which evidently adheres to the lower surface of one of the segments of the siphuncle. The two overlying septa in a similar manner are in contact with the base of the two following segments of the siphuncle. The dorsal sides of the second and third of these segments is outlined distinctly, but there is no line of demarcation between the lowest segment of the siphuncle and that part of the septum which is adnate to the lower part of its dorsal side. The fourth and fifth septa from the base of the specimen are distinctly indicated on the right side of the specimen, as figured, but the corresponding segments of the siphuncle are only very obscurely indicated. The most striking feature of the specimen is the downward protrusion of the central part of septum at its base, in a manner similar to that of a septal neck. The central part of this protrusion apparently is occupied by a circular opening about 9 mm. in diameter. This central opening is interpreted as the lower end of the so-called endosiphuncle. Owing to the ventrad slope of the septum at the base of the specimen, this circular opening faces obliquely downward in a dorsad direction, very much as in figure 22 (b) on page 165 of the Catalogue by Foord, cited above.

Locality and Horizon.—Igloolik Island, Fox Channel, Arctic America; possibly from strata of about the same age as those exposed at Cape Calhoun, north of the Kane Basin, in the northwestern part of Greenland. By Troedsson, the latter are regarded as of Richmond age. Specimen No. 33452 in the British Museum of Natural History.

Remarks.—Compared with *Kochoceras cuneiforme* Troedsson,[29] the rate of lateral enlargement of the conch is similar, but the size of the conch is much smaller, and the number of camerae in a length equal to its lateral diameter is less.

36. **Ormoceras** sp. (Arctic America)

Plate XXV, figs. 3 A, B, C

Ormoceras (?) sp., Foerste, Jour. Sci. Labs. Denison Univ., 22, pl. 2, fig. 3 (1927).

Specimen 43 mm. long, consisting of about 18 camerae, of which the lower 12 are distinctly defined and show traces of the siphuncle and of various calcareous deposits, the following 4 show only their outlines, and the last 2 are very obscurely indicated. The specimen enlarges from a diameter of 5.8 mm. at its base to 10.8 mm. farther up, indicating an apical angle of 10 degrees.

The number of camerae in a length equal to the diameter of the conch varies from about 4 to 4.5; since the siphuncle is only moderately excentric in position it is assumed that the sutures of the septa of this specimen are directly transverse, or nearly so. At one point, where the diameter of the conch is 10 mm., the vertical strand at the center of the siphuncle, usually known as the endosiphuncle, is located 4.5 mm. from one wall of the conch and 5.5 mm. from its opposite side. From this central vertical strand more or less horizontal lamellae extend outward. These frequently are interpreted in other actinoceroid cephalopods as tubuli. Not uncommonly, in vertical sections, they present the appearance of transverse septa, but they occur at levels distinctly different from that of true septa, either at mid-height of

[29] Gustaf T. Troedsson. On the Middle and Upper Ordovician Faunas of Northern Greenland, pt. 1, Cephalopods, 68, pls. 37, 38, 39, 40, 44 (1926).

the segments of the siphuncle or slightly above mid-height. The inner terminations of the septa at the septal necks are not clearly defined, but the location of these septal necks is indicated approximately by the radiate structure traversing the annular deposits which line the inner sides of these necks, as seen in vertical sections, and from this it is assumed that the constrictions of the siphuncle at the septal necks were 3 mm., or slightly more than 3 mm. in diameter. The so-called tubuli locate the lines along which the calcareous deposits surrounding successive septal necks met. These so-called tubuli expand at their outer ends in a triangular manner, with a lunate outline exteriorly, the latter locating the exterior wall of the nummuloidal segments of the siphuncle. From this it is inferred that the maximum diameter of the nummuloidal segments at the point under investigation was 4.7 mm. At the top of the twelfth camera from the base of the specimen, on the right side of the siphuncle, the septal neck appears distinctly defined; if so, it is very short, possibly a fifth of a millimeter or less in length, being abruptly curved outward at its lower margin. The camerae are partly filled with crystalline calcite which lines the interior side of their walls, and also by very fine-grained matrix, similar to that occupying the more central parts of the conch. These finer grained deposits join the triangular-lunate deposits at the end of the so-called tubuli, described above, indicating that the outer walls of the nummuloidal segments of the siphuncle may have been weathered away before the finer grained matrix filled the spaces remaining vacant. These vacant spaces include not only the inner parts of the camerae and the triangular terminations of the tubuli, but also the tubuli themselves, and the central strand known as the endosiphuncle. As a rule, the vacant spaces within the siphuncle are distinctly separate from the camerae, and receive their final deposits from the upper part of the siphuncle, after the death of the animal. In the specimen under investigation, the crystalline calcite deposits predominate at the apical end of the specimen, while the fine grained matrix increases relatively toward its top.

Locality and Horizon.—From the Silurian of Arctic America.

Collected by Capt. H. W. Feilden, on the Expedition of the "Alert" and "Discovery," during the years 1875–76. Specimen no. 89175 in the British Museum of Natural History.

The matrix of this specimen contains a fragment of a *Syringopora*, with corallites 1.8 mm. in diameter. Apparently this species is identical with the one figured by Rev. S. Haughton[30] under the name *Syringopora geniculata*, from Cornwallis Island, where only Silurian is exposed. The same species of *Syringopora* is cited by Haughton also from Griffith's Island and from the west coast of King William Land. At Griffith's island only Silurian is known. Along the west coast of King William Land both Ordovician and Silurian appear to occur.

Remarks.—This specimen evidently shows the same type of structure as that shown by *Ormoceras bayfieldi* Stokes, but it is much smaller in size. The siphuncle is sub-central in position, and its segments approach the depressed globular, rather than the broadly nummuloidal form. The details preserved best include the so-called radiating tubuli whose outer ends join the inner parts of the deposits of matrix filling the interior of the camerae. Previous to fossilization the inner walls of these camerae were lined with calcareous deposits. These deposits were thicker in the lower camerae, so that the deposits of matrix within the camerae become progressively broader on passing to successively higher camerae. In the present condition of fossilization of the specimen the outlines of the walls of the siphuncle and of the septa are more or less obscured, but their former course may be determined from the distribution of the calcareous deposits and of the matrix filling the remaining spaces in the interior of the conch.

From such a small fragment it is impossible to determine definitely the relationship of the specimen here described. Compared with *Ormoceras bayfieldi*, the camerae are taller and the siphuncle was relatively broader.

[30] Samuel Haughton. Description of the Plates to Illustrate the Geology of Captain M'Clintock's Ice-Travels; in Journ. Royal Dublin Soc., 1, pl. 11, fig. 2 (1857).

37. **Armenoceras lyoni** (Stokes)

Plate XIII, fig. 2 pl. XIV, fig. 1 pl. XXIV, fig. 1 A, B

Actinoceras lyonii Stokes, Trans. Geol. Soc. London, (2), 5, 707, pl. 59, fig. 1 (1840).

Actinoceras Bigsbyi Foord, Cat. Foss. Cephalopoda British Museum, pt. 1, 168 (1888).

Specimen 100 mm. long, enlarging from a lateral diameter of 45 mm. near its base to 58 mm. at a point 76 mm. farther up. About 6.5 camerae occur in a length equal to lateral diameter of the conch. The lateral sides of the specimen are preserved for a width of 15 mm., and these sides expose the sutures of the septa. These sutures are approximately horizontal, as far as can be determined from such a small width. The dorsal face of the specimen is weathered flat, producing a natural section passing vertically through the center of the siphuncle in a lateral direction. This siphuncle is 33 mm. in diameter along the upper part of the specimen where the lateral diameter of the conch is 52 mm., equalling almost two-thirds of the width of the latter. At the septal necks the diameter of the siphuncle is contracted to about 25 mm. The septal necks are relatively short, and from 1 mm. to 1.5 mm. in length. The vertical outlines of the segments of the siphuncle are evenly convex. The ventral side of the specimen also is weathered flat. It exposes the ventral margins of the segments of the siphuncle and the full width of the septa. These septa are adnate to the lower surface of the segments of the siphuncle and their downward curvature equals almost the length of one camera. The siphuncle apparently is nearly central in location within the conch.

Locality and Horizon.—Igloolik Island, Fox Channel, Arctic America; at probably the same Ordovician horizon as that containing *Kochoceras mantelli* and *Kochoceras foordi*. This species was named after Captain Lyon, who collected specimens at Igloolik Island— where Sir Edward Parry's Expedition wintered in 1822–23. This specimen is numbered 34046 in the British Museum of Natural History.

Remarks.—The structural features characterizing this species are shown by the figures kindly prepared by Dr. F. A. Bather, Keeper of the Geological Department of the British Museum. These are reproduced on plate XXIV, the larger figure illustrating the structure on the side figured by Stokes, exposing a natural section passing through the center of the siphuncle, while the smaller figure was taken from the ventral side of the specimen, recently rubbed down at the Museum for the purpose of better exposing the structure on this side.

38. **Armenoceras richardsoni** (Stokes)

Plate XXI, fig. 1

Actinoceras Richardsoni Stokes, Trans. Geol. Soc. London, ser. 2, vol. 5, pt. 3, 708, pl. 59, figs. 2, 3; also Foord, Cat. Foss. Cephalopoda in British Museum, pt. 1, 172 (1888).

The specimen is broken; the upper part is 83 mm. long, and the lower part is 100 mm. long, their combined length being 170 mm. The specimen consists of the ventral half of a conch. The maximum width of the upper half of the specimen, as far as preserved, is 76 mm. The rate of enlargement of the conch, judging from the rate of enlargement of the siphuncle, is very small. About 8.5 camerae occur in a length equal to the lateral diameter of the conch. The sutures of the septa are almost directly transverse, but on the ventral side of the conch they appear to curve downward about 3 mm., thus producing a very shallow but broad ventral lobe. The concavity of the septa is about 15 mm. The distance of the siphuncle from the ventral wall of the conch is 3 or 4 mm. The diameter of the siphuncle is 35 mm. at a point where the lateral diameter of the conch is 76 mm. The siphuncle enlarges from a diameter of 33 mm. at the base of the lower part of the specimen to 34.5 mm. at a point 145 mm. farther up. Four segments of the siphuncle occur in a length equal to their diameter. The septal necks are short, usually about 1 mm. in length, but sometimes 1.5 mm. long. The vertical lateral outlines of the segments of the siphuncle are evenly convex. No markings belonging to the surface of the shell are preserved.

Locality and Horizon.—Lake Winnipeg, Manitoba, Canada; probably from the same horizon as that regarded as of Richmond age in the Cape Calhoun series of northwestern Greenland by Prof. Gustaf Troedsson; formerly referred to the Galena-Trenton on account of the presence of *Receptaculities oweni* Hall. Specimen No. 33422, in the British Museum of Natural History.

39. **Armenoceras sphaeroidale** (Stokes)

Plate XXVIII, figs. 1 A, B

Armenoceras sphaeroidale Foerste, Jour. Sci. Labs. Denison Univ. 22, pl. 3, fig. 5 (1927).

Cf. *Huronia sphaeroidalis* Stokes, Trans. Geol. Soc. London, 2nd ser., 1, pt. 2, 203, pl. 28, fig. 5 (1824).

Specimen consisting of a triangular fragment from the right ventro-lateral side of a conch. It exposes the ventro-lateral margins of three of the segments of the siphuncle, a trace of the overlying fourth segment, and the various septa extending from this part of the siphuncle toward the ventro-lateral part of the surrounding shell.

Judging from the transverse curvature of the shell in the small fragment at hand, the diameter of the conch was about 105 mm. In a similar manner, the diameter of the siphuncle is estimated at 55 mm. The siphuncle apparently does not approach closer than 5 mm. to the nearest part of the ventral wall of the conch. Four camerae occupy a length of 62 mm. From this it is estimated that 7 camerae occupied a length equal to the diameter of the conch. The sutures of the septa curve downward strongly on the ventral side of the conch. It is estimated that the depth of their concavity equals at least the length of 1.5 camerae, and may equal 2 camerae. The lateral outlines of the siphuncle show a curvature in a vertical direction corresponding to a radius of 7 or 8 mm. At a point 7 mm. back from the greatest outward extension of the nummuloidal segments of the siphuncle, adjacent segments are only 0.8 mm. apart. From this it is evident that the septal necks were very short, and probably flared out abruptly at their lower margins. The diameter of the passage of the

siphuncle through the septum, at the septal neck, is unknown, but it evidently was considerably less than 40 mm., since at a distance of 7 mm. from the outer margin of the segments of the siphuncle the vertical section parallel to the tangent exposes only the elliptical outlines of these segments. The interior of the siphuncle is filled with calcareous deposits. No surface markings are shown by the shell.

Locality and Horizon.—In the British Museum of Natural History two specimens are numbered C 2712. They are labelled *Actinoceras ? backi* (Stokes), and were collected by the expedition of the "Alert" and "Discovery" during the years 1875–76 from the Silurian of some unknown part of Arctic America. The specimen here described, which I have lettered B, is identical lithologically with that numbered C 2715. The latter is known to have been obtained at Dobbin Bay during the same expedition. Therefore, specimen C 2712 B probably is at least from the same horizon, and may have come from the same locality.

Remarks.—Among described species, *Armenoceras sphaeroidale* (Stokes) presents a somewhat similar aspect. *Actinoceras cochleatum* (Schlotheim), probably also an *Armenoceras*, differs in having its siphuncle in actual contact with the ventral wall of the conch.

The identification of the specimen here described under *Armenoceras sphaeroidale* is not very satisfactory. The structure of the interior is not known satisfactorily either in the case of the type of the species or in the Dobbin Bay specimen. It should be noted in this connection that *Nybyoceras bekkeri* Troedsson,[31] described from the Lyckholm beds at Byby, Esthonia, would present a similar section if cut tangentially to the segments of the siphuncle rather close to the septal necks.

40. **Armenoceras** (?) **ommaneyi** (Salter)

Plate XIII, figs. 3, 4

Orthoceras Ommaneyi Salter, in Sutherland's Voyage to Baffin Bay and Barrow's Straits, 2, ccxxii, pl. 5, figs. 16, 17 (1852).

[31] Gustaf T. Troedsson. On the Middle and Upper Ordovician Faunas of Northern Greenland, pt. 1, Cephalopods, 106, pl. 63, figs. 1-3 (1926).

Orthoceras Ommaneyi Haughton, Jour. Royal Dublin Soc., 1, 249, pl. 11, fig. 5 (1857).

Endoceras ? *Ommaneyi* Foord, Cat. Foss. Cephalopoda British Museum, 1, 155 (1888).

The following is the original description by Salter:

> This fine large species seems to be frequently met with, and will easily be recognized by its large lateral siphuncle, and its waved and close septa. It must have been a foot long, and one inch and three-quarters wide. The shell tapers slowly, and has a round transverse section. The septa are placed obliquely, the side farthest from the mouth of the shell being that in which the large siphuncle is placed, and externally they show a downward course in this side. They are very closely placed; in a specimen of an inch and a quarter diameter there are nine in the space of barely an inch. The septa are flattish, and the large siphuncle is placed less than half its own diameter from the edge. It would belong to the section *Cameroceras*.
>
> Localities.—Assistance Bay (Mr. Donnett and Dr. Sutherland).

Two figures are presented by Salter. The larger of these is an inch and a sixteenth or 27 mm. in diameter. The passage of the siphuncle through the septum is almost 7 mm. in diameter, and the distance from this passage to the ventral wall of the conch is almost 3 mm. In the text this figure is numbered 16, but on the plate it is numbered 17. The second figure represents a phragmacone. The figure is 50 mm. long and enlarges from a diameter of 9 mm. at its base to 14.5 mm. at its top. About 8 camerae occur in a length equal to the diameter of the conch. The sutures of the septa show an upward flexure along the middle of the figure, but it is not known how the specimen is oriented in this figure.

Salter referred his species to *Cameroceras*. It is not known, however, upon what basis this reference was made. Apparently his reference was based solely on the large size of the passage of the siphuncle through the septum, the proximity of this siphuncle to the ventral wall of the conch, and the downward course of the sutures of the septa on this ventral side. Apparently he had no knowledge of the structure of its siphuncle.

At least, in 1857 Haughton published a figure (pl. XI, fig. 5) of the vertical section in a dorso-ventral direction through the center of the siphuncle of some conch which he identified with *Orthoceras*

Ommaneyi,[32] accompanied by the following statement in the text:

> This specimen was found in the Upper Silurian limestone of Assistance Bay, and is figured by me to show that it has a beaded siphuncle, a circumstance not noticed by Mr. Salter in his description, but which is well shown in the polished section from which my figure is sketched.

Unfortunately, Haughton's figure suggests a cyrtoceroid, with a convexly curved ventral outline, the dorsal outline being relatively straight, and the passage of the siphuncle through the septa is relatively much smaller, being only about 3 mm. where the dorso-ventral diameter of the conch is 20 mm., so that Haughton may have figured an entirely distinct species. However, the mere fact that he published this figure, and that the actinoceroid nature of the siphuncle of *Orthoceras ommaneyi* remained unchallenged after his publication suggests that Salter's reference of his species to *Cameroceras* was not founded on any knowledge of the structure of its siphuncle beyond that contained in his original description.

Foord, in the publication cited above stated:

> There are two small fragments in the Collection (of the British Museum) labelled with the above name (*Orthoceras Ommaneyi*), one of them with a reference to Salter's figure, but neither of them is the type. They are both young examples, one (No. 96966) being in fact the apical extremity, and measuring not much more than 2½ inches in length; the septa are very close, there being nine in the space of an inch. The other specimen (No. 96954) shows the siphuncle in section, and this is found to be somewhat less than one fourth the diameter of the shell.

In the first of these specimens, containing 9 septa in the space of an inch, the maximum diameter at this point is not quite three-quarters of an inch, instead of five-quarters as in the specimen described by Salter. In the second specimen, moreover, the siphuncle was exposed only along the septum at the top of the fragment, without presenting a view of its structure within the camerae. Recently a vertical section was cut through both of the specimens studied by Foord, revealing nummuloidal segments in both. However, only the second of these specimens has sutures

[32] Samuel Haughton. Description of the Plates to Illustrate the Geology of Captain M'Clintock's Ice Travels; Journ. Royal Dublin Soc., 1, pl. 11, fig. 5 (1857).

which curve conspicuously downward on the ventral side of the conch. Since this second specimen (No. 96954) agrees very well also in the other features recorded by Salter in his original description, it is selected here as the future type of the species, to replace the original type whose recovery appears very unlikely.

The specimen described first by Foord (No. 96966) belongs to a distinct species with almost directly transverse sutures, and with a siphuncle which is in contact with the ventral wall of the conch. For this specimen the name *Armenoceras donnetti* is proposed on one of the following pages.

41. **Armenoceras** cf. **ommaneyi** (Salter)

Plate XIII, figure 5 A, B; pl. XXIV, fig. 2 A, B, C

Endoceras ? *Ommaneyi* Foord (pars), Cat. Foss. Ceph. British Museum, 1, 155 (1888).

Armenoceras cf. *ommaneyi* Foerste, Jour. Sci. Labs. Denison Univ., 22, pl. 4, fig. 6 (1927).

Specimen 33 mm. in diameter at its top, with a total of 17 camerae in a length of 44 mm. The number of camerae in a length equal to the diameter of the conch is 12. The rate of enlargement of the conch cannot be determined with accuracy, but it is estimated that the apical angle was somewhere near 6 degrees.

Only the ventral half of the phragmacone is preserved, and on this side the sutures of the septa curve strongly downward, for a distance of 1.5 camerae below their level on the lateral sides of the conch. The downward curvature of these sutures along the lateral sides of the phragmacone was distinctly less, so that it may have been still smaller on its dorsal side, though they probably sloped all the way from the dorsal toward the ventral side.

The siphuncle, at its most constricted part, where passing through the septa, was 9.2 mm. in diameter, the nearest portion of this constricted part being 3 mm. from the ventral wall of the conch, at the top of the specimen. The segments of the siphuncle are nummuloidal in form. On their ventral side they extend 1.7 mm. beyond a vertical line passing through the most constricted part of the septal necks, so that the nearest part of these

segments is 1.3 mm. distant from the ventral wall of the conch. If the nummuloidal extension of the segments of the siphuncle on the dorsal side of the conch was equal in degree, then the maximum diameter of these segments at the top of the specimen was about 12.5 mm.

In a vertical section passing through the center of the siphuncle in a dorso-ventral direction the ventral wall of the nummuloidal segments is outlined distinctly within the upper 4 camerae, and partially in some of the remaining camerae. On the dorsal side of the siphuncle,—on the contrary, the wall of these segments is defined distinctly only within the fourteenth camera from the top. The septal necks are of very short length and flare abruptly outward at their lower margins. They are preserved more frequently than the connecting rings. In no case do they exceed one-fourth of a millimeter in length, and in many cases they curve outward so abruptly at their lower margins that their length apparently did not exceed one or two tenths of a millimeter. The retention of the ventral wall of the segments of the siphuncle, and the frequent absence of their dorsal wall is of interest.

Along the ventral side of the siphuncle the inner margins of the septal necks are enveloped by calcareous deposits which are meager at the upper 4 septal necks, intermediate in amount at the fifth septal neck from the top, and abundant at the remaining septal necks. At the twelfth and thirteenth septal necks the calcareous deposit is about equally abundant above and below this constriction. At the remaining septal necks, from the sixth to the bottom of the specimen, the calcareous deposit is most abundant on the lower side of the constriction. On the dorsal side of the siphuncle there are no corresponding calcareous deposits enveloping the inner sides of the septal necks.

On the ventral side of the siphuncle the septa form an angle of 65 degrees with the vertical axis of the conch. From the siphuncle toward the lateral walls of the conch the septa rise a vertical distance of about 2 camerae. Their rise toward the dorsal side of the conch is not known definitely, but it may be somewhat less.

Locality and Horizon.—From Assistance Bay, on the southeast

coast of Cornwallis Island. Collected by Dr. P. C. Sutherland, in strata recorded as Silurian. Specimen No. 96954, in the British Museum of Natural History.

Remarks.—Compared with *Armenoceras donetti* (specimen no. 96966), also from Cornwallis Island, this specimen may be distinguished at once by the greater distance of the siphuncle from the ventral wall of the conch, there being no actual contact between the two. Moreover, the camerae are more numerous, the sutures of the septa curve more strongly downward on the ventral side of the conch, and the septal necks are much shorter. The rock is very fine-grained, dark gray in color, and resembles that from Griffith's Island lithologically.

Armenoceras ommaneyi, as here identified, resembles *Armenoceras imbricatum* Hisinger in its rate of increase in size, in the obliquity of the sutures of its septa along the ventral side of the conch, in its relatively short camerae, and in the size and structure of its siphuncle. If the structure of the siphuncle in *Armenoceras imbricatum*, as presented by Barrande on his plate 228, is typical of that species, then *Armanoceras ommaneyi* differs in having the upper part of the segments of its siphuncle form a more acute angle with the overlying septum ventrally; moreover, its camerae are relatively shorter, and its siphuncle is narrower.

42. **Armenoceras donetti** Foerste

Plate XXIV, fig. 3 A, B.

Endoceras ? *Ommaneyi* Foord, pars; Cat. Foss. Ceph., British Museum, 1, 155 (1888).

Armenoceras donetti Foerste, Jour. Sci. Labs. Denison Univ., 22, pl. 3, fig. 6 (1927).

Specimen 70 mm. in length, consisting of part of a phragmacone; within this length, 42 mm. exposes the cast of the interior of 16 camerae, while the 28 mm. beneath retains only the impression of the exterior of the conch. The specimen is compressed obliquely, so that the siphuncle is located about half-way between the longer and shorter diameters of the elliptical cross-section. These diameters are 19 and 17 mm. respectively. It is assumed that the original cross-section of the conch was circular. Along

the upper part of the specimen the conch is partly weathered and partly compressed in a direction almost at right angles to the direction of compression of the conch beneath. As far as can be determined from the specimen in its present state, the rate of enlargement of the conch was small, not exceeding 1.5 mm. in a length of 25 mm., suggesting an apical angle of 3.5 degrees.

The shortening of the camerae toward the top of the specimen suggests that the latter was mature, and that the species to which this specimen belonged was small. The two lower camerae occupy a length of 7 mm., the next two of 6 mm., the next seven of 18 mm., the next three of 6 mm., the next one of 2.5 mm., beyond which there remains a space 2.5 mm. long which may have been occupied by another camera. This shortening of the camerae toward the upper part of the specimen is common in specimens reaching maturity. Moreover, the lengthening of the last one or two camerae after a period of shortening has been noted in other specimens of cephalopods, but is rare. If the lower camerae be regarded as indicating the general length of these camerae during the greater part of the length of the phragmacone, then about 6 camerae should occur, in a length equal to the diameter of the conch, along the greater part of the length of this phragmacone.

The sutures of the septa slope moderately downward from the dorsal toward the ventral side of the conch, forming an angle of 85 degrees with the vertical axis of the latter. Where the diameter of the conch is 18 mm., the concavity of the septa is 2 mm., which is relatively shallow. At the constriction of the siphuncle, where it passes through the septum, its diameter is 3.8 mm., and its distance from the ventral wall of the conch is 1 mm. The lower 3 camerae of the specimen were split off from the remainder at the septum limiting this group, and a section was cut vertically through the siphuncle in a dorso-ventral direction. This exposed the segments of the siphuncle, which are nummuloidal in form, enlarging from 3.8 mm. in diameter at the constrictions to 4.5 mm. near mid-height of the camerae. The septal necks have a length of 0.6 mm., their lower margin curving outward strongly. The segments of the siphuncle are in contact with the ventral

wall of the conch apparently for a length of 1.5 mm. Along the dorsal side of the siphuncle only the septal neck with its outward curving lower margin is well exposed, its length being 0.6 mm. The upper part of the connecting ring is much less distinctly preserved, in one camera extending 1.5 mm. beneath the overlying septum. Apparently the preservation of this part of the connecting ring is due to the deposit of fine-grained calcareous material in annular form around that part of the segments of the siphuncle which includes the septal neck and the uppermost part of the connecting ring. The matrix surrounding the specimen and filling the interior of the camerae and of the siphuncle is abundantly supplied with oolitic grains from 0.5 to 0.7 mm. in diameter. These oolitic grains cross that part of the siphuncle where the middle and lower parts of the dorsal wall of the connecting rings should appear. From this it is evident that this part of the dorsal wall had disappeared before the conch became imbedded in its oolitic matrix. No distinct trace of surface markings is shown by the impression left by the exterior of the conch.

Locality and Horizon.—The specimen bears the label: *Orthoceras Ommaneyi*, Cornwallis Island, Upper Silurian. There is also a second label on which the last part of the name of the locality *Cornwallis Island* and the last two figures of the date *1851* appear distinctly. The strata formerly known as Upper Silurian at present are called simply Silurian. The specimen is numbered 96966 in the British Museum of Natural History. It was collected by Dr. P. C. Sutherland. It is named in honor of Mr. Donett, another of the collectors on the same expedition.

Remarks.—The matrix surrounding this specimen encloses *Leperditia arctica* Jones and also unidentified species of *Entomis* and *Bythocypris*. The *Leperditia* named was described originally from Cape Hotham and Assistance Bay, both on the southeast shore of Cornwallis Island.

Orthoceras Ommaneyi Salter.—Salter described *Orthoceras Ommaneyi* as 1.75 inch wide, with 9 septa in barely an inch. This is equivalent to 10 camerae in a length equal to the diameter of the conch.

His original description is accompanied by two figures, of which figure 17 presents a view of the septum seen from beneath and exposing the passage of the siphuncle. The lateral diameter of this siphuncle is one inch and the dorso-ventral diameter is a sixteenth of an inch longer. The diameter of the most constricted part of the siphuncle, at the septal neck, is a quarter of an inch. The downward curvature of the septal neck begins about a sixteenth of an inch from this wall. This figure is regarded as typical of the species.

It is not certain that the specimen illustrated by figure 18 belongs to the same species, though this may be assumed in the absence of the original of this figure. It represents the dorsal side of the phragmacone. Its diameter at the top is nine-eighths of an inch. The apical angle is nearly 7 degrees. The number of camerae in a length equal to the diameter of the conch is only 8. The sutures of the septa rise on this side above their level on the lateral sides of the conch about the height of one camera, suggesting that they rise the height of 2 camerae above their level on the ventral side of the conch.

The chief difference between the specimen described above and the second figure presented by Salter is the smaller number of its camerae, there being only 7 in a length equal to the diameter of the conch; this difference is insignificant.

43. **Armenoceras coppingeri** Sp. nov.

Plate XII, fig. 1; pl. XXIV, fig. A, B.

Orthoceras imbricatum Etheridge (non Wahlenberg), Quart. Journ. Geol. Soc. 34, 607 (part under D 12′) (1878).

Actinoceras sp. Foord, Cat. Foss. Ceph. British Museum, 1, 184 (1888).

Specimen 133 mm. long, originally several millimeters longer, but the lower end was shortened by grinding and polishing in order to secure a transverse section of the siphuncle. Only the ventral half of the specimen remains, the interior of the conch being exposed by weathering along a section in a lateral direction through the center of the conch. Recently a vertical section,

about 40 mm. long, was cut in a dorso-ventral direction through the center of the siphuncle, and one side of this section was polished.

The transverse section of the conch appears to have been circular. The rate of enlargement of the conch is shown approximately by estimates of its diameter at 10 mm. above its base, at 35 mm. farther up, and at 50 mm. above the second point. These estimates are respectively 40 mm., 44 mm., and 50 mm., indicating an apical angle of about 7 degrees.

The number of camerae in a length equal to the diameter of the conch at the top of the series being counted is 8. At the break across the specimen at the top of the polished vertical section, the elevation of the suture of the septum is the same along the ventral side of the conch as along its lateral side, indicating that the sutures are directly transverse. The septa are strongly concave, their concavity equalling almost the height of 2 camerae.

Where the diameter of the conch is 44 mm., the passage of the siphuncle through the septum is 16 mm. in diameter. In the vertical section the lateral outline of the nummuloidal segments of the siphuncle extends outward 3 mm. beyond a vertical line passing through the margins of the constrictions of the siphuncle at the septal necks. This indicates a maximum diameter of 22 mm. for the nummuloidal segments at the point where the diameter of the conch is 44 mm. At its nearest point, the nummuloidal segment is 3 to 4 mm. from the ventral wall of the conch. The septal necks are very short, their lower margin curving outward abruptly within less than a quarter of a millimeter from the septum from which they originate. At the top of the polished fragment the connecting ring is outlined distinctly, but the course of some of the lower connecting rings may be traced also, though with much more difficulty.

The center of the siphuncle is traversed by a strand about 1.5 mm. in diameter, known as the endosiphuncle. From this, numerous vertical lamellae appear to radiate outward for a distance of 5 mm. Exterior to this the structure of the deposits filling the interior of the siphuncle is distinctly concentric. In the polished vertical section these concentric lamellae are seen to

curve more or less rhythmically, the amount of this curvature increasing in the immediate vicinity of the septal necks which they envelop to a greater or less degree. A considerable part of the structure in the immediate vicinity of the walls of the siphuncle has been obliterated by the recrystallization of the calcite.

Locality and Horizon.—The specimen is numbered C 2714, in the British Museum of Natural History, and bears the label: *Dobbin Bay, 14th Aug., '75, E. shore, D. 12'.*

Dobbin Bay is located directly north from Etah, approximately west of the middle of Kane Basin, in the southern part of Grinnell Land. Grinnell Land is part of that large island west of Greenland known as Ellesmereland. It includes that part of Ellesmereland which is west of Kane Basin and of Kennedy Channel. That part of the island which is north of Grinnell Land is known as Grant Land, and that part which is south of Grinnell Land is that part to which the term Ellesmereland originally was limited. The mouth of Dobbin Bay is located near 73° west longitude, between 79° 30′ and 79° 40′ north latitude. Here both H. W. Feilden and Dr. R. W. Coppinger collected fossils during the Expedition of the "Alert" and "Discovery" in the years 1875–76. The specimen here described was collected by Dr. Coppinger.

According to H. W. Feilden, the naturalist of the expedition, fossils were collected at 79° 40′ north latitude at the Dobbin Bay locality. According to his account, the raised beaches in the bay between Cape Hilgard (at 79° 41′ north latitude) and Cape Napoleon (at 79° 38′ north latitude) were formed of limestone debris replete with fossils. Cape Hilgard forms the northern edge of the mouth of Dobbin Bay, at 72° 45′ west longitude, and Cape Louis Napoleon is located directly east of the latter, at 72° 15′ west longitude.

In his account of the Paleontology of the Coasts of the Arctic Lands visited by the late British Expedition under Captain Sir George Nares[33] (Geol. Soc. London, Quart. Journal, 34, 607 (1878)), Robert Etheridge refers the specimen here described to *Orthoceras imbricatum*, and in the list of fossils facing page 635, this species is recorded only from Dobbin Bay in latitude 79° 40′.

[33] Robert Etheridge, Geol. Soc. London, Quart. Journ., 34, 607 (1878).

This Dobbin Bay locality is regarded by Etheridge as of Silurian age. Specimen C 2716, also referred to *Orthoceras imbricatum* by Etheridge, was obtained farther eastward, at Cape Louis Napoleon.

Remarks.—*Armenoceras coppingeri* is similar to *Armenoceras ommaneyi* in the structure of its siphuncle, in the relative distance of this siphuncle from the ventral wall of the conch, and in the shortness of its camerae. In both species the ventral outline of the segments of the siphuncle is almost evenly convex; where their lower faces come in contact with the septa beneath, the latter are almost straight; the reversal of curvature at the septal necks is so abrupt that the latter scarcely can be said to have any length; and the upper part of the segments makes a very acute angle with the septum immediately above. *Armenoceras coppingeri* differs from *Armenoceras ommaneyi*, however, in the relatively insignificant downward curvature of the sutures of its septa along the ventral side of the conch, and in the relatively larger size of its siphuncle. These differences distinguish *Armenoceras coppingeri* also from *Armenoceras imbricatum* Hisinger.

44. **Armenoceras** cf. **rotulatum** (Billings)

Plate XXV, fig. 5.

Orthoceras nummularium Etheridge, Quart, Jour. Geol. Soc. London, 34, 608 (1878).

Actinoceras Backi Foord, Foss. Cephalopoda British Museum, 1, 183 (1888).

Armenoceras sp., near *Huroniella*, Jour. Sci. Labs. Denison Univ., 22, pl. 16, fig. 4 A, B (1927).

Specimen consisting of a fragment of the siphuncle including 7 segments in a length of 67 mm., only a fragment of the lowest segment being preserved. Its diameter is 30 mm. and there are 3 segments in this length. The segments form an angle of 83 degrees with the vertical axis.

The specimen has been sectioned vertically through its center, in a dorso-ventral direction. Along its dorsal outline the curvature of the segments is nearly evenly convex, with a radius of

curvature of 5 mm. Along its ventral outline the maximum curvature of the segments lies three-fifths of their height, or slightly more, above the base of the segment. For a vertical distance of about seven-tenths of the height of the segment its ventral outline is fairly evenly convex with a radius of curvature of 4 mm., but along the lower half of the segment its ventral outline is faintly concave, and forms an angle of about 45 degrees with the vertical axis. The septum evidently was adnate to the concave part of the ventral side of the segment, up to the point where its curvature began to change from concave to convex. Along the dorsal side of the siphuncle, the septum evidently was adnate only to the lower face of the annulation of the segment, and therefore rose to a much smaller height along its upper line of contact. The specimen shows the usual structure shown by the siphuncle of *actinoceroids* when filled by calcareous deposits, including the so-called endosiphuncle and the tubuli.

Locality and Horizon.—The specimen bears the label: *Bessels Bay, Aug. 23, '75, H. W. F.*, and also a crescent curving toward the left. The specimen evidently was collected by Capt. H. W. Feilden on the Expedition of the "Alert" and "Discovery" made during the years 1875–76. Bessels Bay is located on the northwest coast of Greenland, at the northern end of Kennedy Channel, directly west of Petermann Fiord. Its mouth is located at 81° 6′ north latitude and 63° 45′ west longitude. The specimen probably was obtained near the mouth of the bay but on its eastern side, since it is only this eastern side which is represented as exposing Silurian strata on the geological map published by Etheridge.[34]

The specimen is numbered C 2713, in the British Museum of National History, where it is listed as *Actinoceras rotulatum* Billings. It occurs in a white limestone which contains fragments of some stromatoporoid. Robert Etheridge, on page 590 of the publication cited above, states that "The white limestones of Bessels Bay contain *Stromatopora* and a *Lithostrotion* associated with crinoidal fragments. No statuary marble is whiter than

[34] Robert Etheridge, Geol. Soc. London, Quart. Journ., 34, pl. 24 (1878).

these perishable limestones, which readily fall to pieces upon handling." Its horizon is Silurian.

A similar specimen apparently was described by Etheridge on page 608 of the publication cited above, under the name *Orthoceras nummularium*, but his specimen is stated to have been collected by Dr. R. W. Coppinger, who took part in the same expedition. The fact that Etheridge lists only 6 siphuncular chambers calls attention to the fact that in the specimen collected by Capt. H. W. Feilden, here described, only the 6 upper segments of the siphuncle are well preserved, only one side of the lowest or seventh segment remaining. Foord referred the specimen described by Etheridge to *Actinoceras backi* Stokes, and refers *Orthoceras rotulatum* Billings to the same species.

Remarks.—This is a definitely known siphuncle, showing clearly both the exterior outlines and the internal calcareous deposits. The line along which the septa, adnate to the lower side of the segments of the siphuncle, become free from the latter is indicated more or less distinctly on the dorsal side of the segments, and may be inferred along its ventral side, but there is no trace of the free parts of the septa nor of any part of the conch.

In *Actinoceras nummularium* (Sowerby), the siphuncle is subcentral in position, its segments are directly transverse to the vertical axis of the conch, and about 4 of these segments occur in a length equal to their lateral diameter.

In Actinoceras backi (Stokes) not quite 3 segments occupy a length equal to the lateral diameter of the siphuncle.

In *Actinoceras rotulatum* (Billings) 3.5 segments occur in a length equal to the lateral diameter of the siphuncle, and they form an angle of 70 degrees with the vertical axis.

In the Bessels Bay specimen here described there are almost 3.5 segments in a length equal to their lateral diameter, but their obliquity to the vertical axis produces an angle of 80 degrees. Among the three species named above, it is related most closely to *Actinoceras rotulatum*, but the obliquity of the segments of its siphuncle is much less.

Among the species recently described by Parks from the Silurian southwest of Hudson Bay, *Actinoceras inflecta* (Parks) pre-

sents a similar aspect. There are slightly over 3 segments of the siphuncle in a length equal to their diameter, but the septa are adnate to the lower half of these segments for fully half the height of the latter, producing a distinctly concave inflection, while in the Bessels Bay specimen this concave part of the outline forms a smaller part of the height of the segments.

The Bessels Bay specimen is regarded as belonging to a new species, but as not preserving enough of the conch to serve as a type.

45. **Armenoceras** sp. (Dobbin Bay)

Plate XII, fig. 3

Specimen consisting of a small triangular fragment from the left ventro-lateral side of the conch. It exposes 3 segments of the siphuncle, also part of an additional segment beneath and of another above this group of 3, and also the septa between this part of the siphuncle and the nearest part of the outer shell of the conch.

It is estimated that at the lower end of this fragment the diameter of the conch was 40 mm., and that of the siphuncle was 21 mm. The latter was not in contact with the wall of the conch, approaching not closer than 1 mm. to the latter. The conch apparently enlarged rather rapidly in diameter, but its rate of enlargement cannot be determined accurately.

Three segments of the siphuncle occupy a length of 22 mm. This suggests slightly more than 5 camerae in a length equal to the diameter of the conch. There is no evidence of any conspicuous downward curvature of the sutures of the septa on the ventral side of the conch, though there may have been a slight downward curvature on that side. The septa are strongly concave. The depth of their concave curvature is estimated to have equalled at least the height of 1.5 camerae, and possibly to have exceeded this amount.

Along a vertical section passing through the center of the siphuncle in a lateral direction, the outline of the nummuloidal segments of the siphuncle appears almost evenly convex, along

its dorsal side with a radius of curvature of 2.5 mm. Along the ventral side of the segments, however, the lower part of the vertical outline is slightly concave. This part forms an angle of 25 or 30 degrees with the adjacent wall of the conch. The septum is adnate to the segments along this slightly concave part of their vertical outline, and its free part continues along the same direction as far as the wall of the conch. Above the point where the septum becomes free from the segments of the siphuncle, the vertical outline of the latter is evenly convex. Along the lateral side of the siphuncle the septum is adnate to the segments of the siphuncle only along their lower side, possibly for a vertical distance of one-fourth the height of the segment, although the amount appears less.

The interior of the siphuncle is filled with a calcareous deposit, showing faint traces of the so-called tubuli within the annular parts of the segments. Relatively thin calcareous deposits also line the upper and lower surfaces of the septa, obscuring the course of the latter.

Locality and Horizon.—This specimen is numbered C 2715 in the British Museum of Natural History, and bears the label: *Dobbin Bay, 14th Aug., 75 E. shore, D 14 (37)*. It was collected by Dr. R. W. Coppinger at the date mentioned in the vicinity of Cape Hilgard, near the mouth of Dobbin Bay, in the southern part of Grinnell Land, west of the center of Kane Basin, directly north of Etah, across the basin.

In the report by Robert Etheridge[35] the latitude of Cape Louis Napoleon is given as 79° 38′, that of the fossil locality on Dobbin Bay as 79° 40′, and that of Cape Hilgard as 79° 41′. It is difficult to reconcile this more southern location of the Dobbin Bay locality compared with that of Cape Hilgard, without the assistance of more detailed maps. Feilden stated[36] that "A northeast anticlinal passing through Cape Hilgard probably brings in older Silurian rocks, as some of the fossils from this locality have been determined by Mr. Etheridge to be *Lower Silurian* (Ordovician) forms: *Maclurea magna, Receptaculites occidentalis, R. arctica,*

[35] Robert Etheridge, Geol. Soc. London, Quart. Journ., 34 (1878).

[36] H. W. Feilden, in Capt. G. S. Nares, Voyage to the Polar Sea, 2, 329 (1878).

Eth." According to Etheridge[37] Silurian fossils occur also at Cape Hilgard, while from the Dobbin Bay fossil locality of Feilden he lists only Silurian forms, and no Ordovician ones.

Remarks.—This fragment is too small to be definitely identifiable, but it is sufficient to indicate the presence of a species with a concave outline along the lower part of the ventral side of the segments of the siphuncle, where the segments are adnate to the septa immediately beneath, while on the dorsal side their outline is evenly convex. This feature shows relationship to the type of structure typical of *Huroniella*.

46. **Armenoceras naresi** Sp. nov.

Plate XIII, fig. 1; pl. XXIII, fig. 1 A–D

Specimen 130 mm. long, consisting of 13 camerae. Its transverse outline is elliptical, with a lateral diameter of 52 mm. and a dorso-ventral one estimated at 42 mm. at the base of the specimen. From this it enlarges to a lateral diameter of 80 mm. and a dorso-ventral one of about 60 mm. at its top. The apical angle in a lateral direction is 12 degrees.

The number of camerae in a length equal to the dorso-ventral diameter of the conch is 7. The sutures of the septa curve distinctly downward on the ventral side, especially between the ventro-lateral parts of the specimen and the median part of its ventral side. The total downward flexure of the sutures equals about half the height of a camera. Along the dorsal side of the conch these sutures appear to have been directly transverse, but this part of the specimen does not expose the sutures. The septa are only moderately concave, the depth of this concavity equaling 14 mm.

The siphuncle is located close to the ventral wall of the conch, but is not in actual contact with the latter. At the base of the specimen its dorso-ventral diameter is 23 mm. and its distance from the ventral wall is fully one millimeter. At this point, also, the constriction of the siphuncle at the septal neck is 13 mm., or slightly over, in diameter, and the center of the con-

[37] Robert Etheridge, in Geol. Soc. London, Quart. Journ., 34 (1878).

stricted open area is 11.5 mm. from the ventral wall of the conch. At the top of the specimen the area within the constriction is 9.5 mm. in diameter dorso-ventrally, and the distance from its center to the ventral wall of the conch is 11 mm. Apparently the siphuncle diminishes in size toward the top of the specimen to a slight degree; at any rate, it forms here a relatively smaller part of the dorso-ventral diameter of the conch.

A vertical section has been cut for a length of 4 camerae through the center of the siphuncle in a dorso-ventral direction. On the dorsal side the septal necks are 1.5 mm. in length vertically. On the ventral side the constriction narrows to a point, so that there can scarcely be said to be a septal neck here. At least, the lower part of this neck curves back so abruptly from the inner margin of its upper part, that the inner margin of the neck scarcely can be said to have any height. On both sides of the siphuncle the lower face of the segments of the siphuncle is adnate to the septum directly beneath, the vertical outline of the segments being concave along this line of contact, but this concavity appears to be more conspicuous along the dorsal side of the segments. The segments are directly transverse to the vertical axis of the siphuncle or vary but slightly from this direction. The interior of the siphuncle is filled with infiltrated matrix, excepting in the vicinity of the inner margins of the constrictions at the septal necks on the ventral side where crystalline calcite apparently replaces the early stages of deposition of calcareous material, the latter having been formed as in other actinoceroids.

There is no evidence of any markings on the surface of the shell, but only the cast of the interior of the phragmacone is at hand.

Locality and Horizon.—This specimen is numbered 83680 in the British Museum of Natural History. No definite knowledge of the origin of this specimen is at hand. It is regarded as probably from some locality in Arctic America. Lithologically the matrix is similar to that which encloses the specimens numbered 96954, C 2126 a and b, C 2712, C 2714, C 2715, C 2716, and 89179, all of which are recorded as Silurian. However, until it is known definitely in what respect the Silurian strata of these areas differ lithologically from Ordovician strata in the same general

areas it is impossible to determine the horizon from which the specimen here described was obtained.

47. **Armenoceras** (?) sp. (Offley Island)

Plate XII, fig. 2; pl. XXIV, fig. 5

Orthoceras imbricatum Etheridge, Geol. Soc. London, Quart. Journ., 34, 607 (1878) (vertically divided half of completely crushed specimen).

Actinoceras Backi Foord, Foss. Cephalopoda British Museum, 1, 183 (1888); (two fragments, Expedition of the "Alert" and "Discovery").

Specimen originally 125 mm. in length and 38 mm. in maximum width, but at present its length is shortened 5 mm. in polishing off a smooth surface at its base. Moreover, a vertical section has been cut for a length of 8 camerae from the base of the specimen in order to show the structure of its interior. In its present condition, the lower 9 camerae occupy a total length of 66 mm., averaging over 7 mm. for the single camera, and these 9 camerae are overlaid by additional camerae successively 4, 7, 4, and 4 mm. in length in ascending order, as though the specimen had reached maturity. The specimen apparently was flattened considerably by crushing, previous to fossilization, so that it is impossible to determine accurately its original diameter, but in its present condition about 8 camerae occur in a length equal to what is assumed to have been approximately its original diameter. The sutures of the septa of that part of the conch which is preserved apparently were directly transverse.

In the vertical sections of the specimen, the septa form an angle of 50 degrees with the vertical axis. They may be traced to a point 13 mm. from the wall of the conch. There is no trace of the siphuncle.

Locality and Horizon.—The specimen bears the label: *Orthoceras imbricatum, Offley Island,* 79° 38′; but the words *Offley Island* are crossed out, and the words *Cape Napoleon* are inserted in a different ink and written by a different hand. If the numbers 79° 38′ be taken as a guide, then the source of this specimen readily could be Cape Napoleon, but not Offley Island.

The specimen here under consideration, numbered C 2716 in the British Museum of Natural History, is the first one of the two specimens described by Robert Etheridge, in his paper on the[38] Paleontology of the Alert and Discovery Expedition, under the name of *Orthoceras imbricatum*, and here the reference is distinctly to Cape Louis Napoleon, Lat. 79° 38′, east of Dobbin Bay, in Grinnell Land. By a peculiar mischance, however, the words *Cape Louis Napoleon, lat. 79° 38′* are repeated in the last line of the same page of Etheridge's paper, following a reference of 4 additional fragments from Offley Island to the same species. Apparently this typographical error and the reference to Cape Louis Napoleon in the last line on this page should be omitted entirely.

Apparently both Ordovician and Silurian strata are exposed at Cape Louis Napoleon. The presence of Ordovician strata is indicated by *Receptaculites arcticus* and *Maclurea magna*, but Robert Etheridge[39] stated that "There seems much doubt as to the horizon at Cape Louis Napoleon from which some fossils come, we certainly have Lower and Upper Silurian (Ordovician and Silurian in present nomenclature) species in the series from this locality."

Remarks.—Judging from the shortening of the camerae toward the top of the specimen the latter had reached maturity. The direct course of the sutures of the septa transversely across the conch excludes it from typical *Armenoceras imbricatum*. The general appearance of the specimen is that of an *Endoceroid*, but in that case all absence of a trace of the siphuncle is anomalous. In some of the northern *Actinoceroids*, on the contrary, the connecting rings between the septa frequently are not preserved along the dorsal side of the siphuncle, for some unknown reason. In the specimen at hand the septa can be traced inward from the sutures for a distance of 13 mm. in a direct line from the wall of the conch. Whether their termination here indicates the ventral limit of the septal necks in unknown.

[38] Robert Etheridge, in Geol. Soc. London, Quart. Journ., 34, 607, 608 (1878).
[39] Robert Etheridge, in Geol. Soc. London, Quart. Journ., 34, 591 (1878).

48. **Huronia occidentale** Sp. nov.

Plate X, figs. 1 A, B; 2

Specimen consisting of the ventral side of a conch, including 10 segments of the siphuncle and the immediately adjacent part of the conch. Judging from the siphuncle, the rate of enlargement of the conch is relatively rapid, but the diameter of the conch cannot be estimated with any degree of accuracy at any point, nor in any direction. The siphuncle is in contact with the ventral wall of the conch, the contact areas being broadly lenticular in outline. The dorsal and lateral sides of the siphuncle present an outline similar to that of *Huronia annulata* Hall,[40] in which the lower part of each segment is relatively short and presents a concave, rather than vertical outline as in the more typical forms of *Huronia*. The septa are adnate to this concave part of the segments and become free along the lower part of the annulations which form the upper part of the segments.

Locality and Horizon.—From Mocassin Mountain, in the Big Horn Range, in Wyoming; in strata regarded as of Richmond age. Specimen in the U. S. National Museum.

Manitoba specimen.—A closely similar specimen consists of a fragment of a siphuncle including 4 segments, in which the annulations forming the upper part of the segments are a little shorter, and the constricted lower parts of the segments are correspondingly longer. From the mouth of Red River, flowing into the southern end of Lake Winnipeg, in southern Manitoba. Specimen No. 4762 in the U. S. National Museum.

Remarks.—This species is conspicuously characterized by the strong flattening of the ventral side of the segments of the siphuncle at contact with the ventral wall of the conch. In *Huronia septata* Parks the annulations are broader in a vertical direction, and the lower half of the segments is less strongly constricted. Moreover, the siphuncle is free from the ventral wall of the conch.[41]

[40] Aug. F. Foerste. Silurian Cephalopods of Northern Michigan; Contributions of Mus. Geol. of Univ. Michigan, 2, no. 3, 48, pl. 6, figs. 1, 3 (1924).

[41] Aug. F. Foerste. Ordovician and Silurian Cephalopods of the Hudson Bay Area. Jour. Sci. Labs. Denison Univ., 22, 71, pl. 12, figs. 1, 2, 4 (1927).

Huronia arctica Troedsson[42] from the Richmond part of the Cape Calhoun series in Kane Basin in northwestern Greenland, has a type of structure similar to that of *Huroniella inflecta* (Parks) as indicated by Troedsson.

Huronia vertebralis Haughton[43] from the west side of King William Land, is similar to *Huronia arctica*, as indicated by Troedsson.[44] However, the annulations of the segments are broader in a vertical direction, and the lower, constricted part of the segments is shorter and more strongly incurved.

49. **Thuleoceras ornatum** Troedsson

Plate VIII, figs. 2–5; pl. XXIII, fig. 8

Cyrtoceras manitobense Schuchert, Proc. U. S. National Museum, 22, 170 (1900).

Thuleoceras ornatum Troedsson, On the Middle and Upper Ordovician Faunas of Northern Greenland, 1920–23, Nr. 1, 94, pl. 1, figs. 3, 4; pl. 55, figs. 4–9 (1926).

This species was described by Troedsson from the Cape Calhoun series of strata, east of Cape Calhoun, on the northeastern shore of Kane Basin, in northwestern Greenland. It is listed by Troedsson from the Trenton member of this series.

The specimens figured by Schuchert from the head of Frobisher Bay, on Baffin Land, are closely similar if not identical. These specimens are numbered 28119 in the U. S. National Museum. Similar specimens, from Apatok Island, in Hudson Strait, numbered 33061, show a siphuncle similar in structure to that figured by Troedsson.

The relationship of *Thuleoceras* to *Westenoceras*[45] cannot be determined until the structure of the siphuncle of the genotype

[42] Gustaf T. Troedsson. On the Middle and Upper Ordovician Faunas of Northern Greenland; pt. 1, Cephalopods, 63, pl. 2, fig. 5, pl. 36, figs. 2, 3; pl. 37, fig. 1 (1926).

[43] Samuel Haughton. On the Fossils brought back from the Arctic Regions in 1859, by Captain Sir F. L. M'Clintock, Journ. Royal Dublin Soc., 3, 57, pl. 2, figs. 1, 2 (1860).

[44] Gustaf T. Troedsson. On the Middle and Upper Ordovician Faunas of Northern Greenland, pt. 1, Cephalopods, 63 (1926).

[45] Aug. F. Foerste. Notes on American Paleozoic Cephalopods. Jour. Sci. Labs. Denison Univ., 20, 253 (1924).

of *Westenoceras* is better known, and until the living chamber of *Thuleoceras* is discovered, but in the present state of our knowledge of these genera they appear to be distinct.

50. **Amphicyrtoceras darwini** (Billings)

Plate XIV, fig. 3 A, B

Orthoceras darwini Billings, Pal. Foss., Geol. Surv. Canada, 1, 161 (adv. sheets, 1861) (1865).

Orthoceras darwini Whiteaves, Pal. Foss., Geol. Surv. Canada, 3, pt. 1, 38, pl. 6, figs. 2, 2a (1884).

Type.—Specimen consisting of the lower part of the living chamber and of a considerable part of the phragmacone. The latter is 62 mm. long and consists of 19 camerae. The specimen is curved lengthwise, the curvature of the upper part of the specimen being slight, but that of the lower part of the phragmacone being distinct, with its ventral outline convex. The specimen is strongly depressed dorso-ventrally, especially along its upper part. It widens laterally so as to produce a gibbous region along the upper end of the phragmacone and the lower part of the living chamber, as in other species of *Amphicyrtoceras*. At the base of the specimen its lateral diameter is estimated at 22 mm. and its dorso-ventral one at 19 mm.; 18 mm. farther up, at the top of the seventh camera from the base, the corresponding diameters are 29 mm. and 23.5 mm.; 42 mm. above the base, or at the top of the fourteenth camera, the corresponding diameters are estimated at 39 mm. and 32 mm.; finally, 62 mm. above the base, or at the top of the nineteenth camera, the lateral diameter is estimated at 47 mm. and the dorso-ventral one was at least 37 mm. Originally, the dorsal side of the specimen, along the top of its phragmacone and along the lower part of the living chamber, must have been distinctly gibbous, but this part of the specimen is not preserved.

The sutures of the septa are relatively straight, but slope moderately downward in a ventrad direction, especially along the lower part of the specimen. Along the upper part of the ventral side of the phragmacone they curve gently downward toward the

median line, forming a broad shallow ventral lobe, as in some specimens of *Amphicyrtoceras laterale* (Hall).[46]

The concavity of the septa is small. At the base of the specimen the center of the siphuncle is about 7 mm. from the ventral wall of the conch at a point where the total dorso-ventral diameter is 19 mm. A vertical dorso-ventral section through the siphuncle failed to give any satisfactory information regarding the structure of its segments.

The lower 7 or 8 camerae are of relatively small height, but the following 3 or 4 camerae increase rapidly in height, the rate of increase in height becoming less again at the top of the phragmacone.

The cast of the interior of the conch is ornamented by about 56 low vertical ribs, similar to those on casts of the interior of *Amphicyrtoceras laterale*, but much more numerous.

Locality and Horizon.—New Hope, now known as Hespeler, in Ontario, Canada; in the Guelph dolomite. Type, numbered 2924 in the collections of the Geological Survey of Canada, in Victoria Memorial Museum.

Remarks.—*Amphicyrtoceras darwini* differs from most specimens of *Amphicyrtoceras laterale* in the considerable distance of its siphuncle from the ventral wall of the conch, but there is considerable variation in this respect among different individuals even of the same species, for instance among different individuals of *Amphicyrtoceras orcas* (Hall). Moreover, in the specimen of *Amphicyrtoceras* figured by Prof. M. Y. Williams,[47] the center of the siphuncle is 7 mm. from the ventral wall, the total dorso-ventral diameter being about 47 mm.

51. **Monocyrtoceras** (?) **arcticum** (Foord)

Plate VI, fig. 1

Cyrtoceras sp., Etheridge, Quart. Jour. Geol. Soc. London, vol. 34, 608 (1878).

[46] Aug. F. Foerste. Notes on American Paleozoic Cephalopods. Jour. Sci. Labs. Denison Univ., 20, 257, pl. 30, figs. 1 A-D, 2 A, B; also p. 255, pl. 29, figs. 1 A-C (1924).

[47] M. Y. Williams. The Silurian Geology and Faunas of Ontario Peninsula and Manitoulin and Adjacent Islands. Geol. Surv. Canada, Memoir 111, pl. 26, fig. 2 (1919).

Orthoceras arcticum Foord, Cat. Foss. Cephalopoda British Museum, pt. 1, 38, text figures 3 a-d (1888).

Specimen about 210 mm. long, approximately circular in cross-section, and gently curved lengthwise. The radius of convex curvature of the ventral outline of the conch is approximately 275 mm. The dorsal outline of the living chamber is straight; but the dorsal outline of the upper part of the phragmacone is slightly concave, with a radius of about 260 mm., beneath which the small part of the phragmacone remaining is only faintly concave. The living chamber apparently is 110 mm. in length, there being a clearly defined septum at this distance beneath the margin of the aperture on its ventral side. Beneath this living chamber there are 4 nearly complete camerae and the dorsal parts of 8 additional camerae. The dorso-ventral diameter of the conch enlarges from 72 mm. at the base of the fourth camera beneath the living chamber to 79 mm. at the base of this chamber, and to 86 mm. at mid-height of the chamber, this diameter remaining the same from mid-height of the chamber as far as the aperture. The corresponding lateral diameters are 71 mm., 75 mm., and 82 mm., apparently decreasing to 77 mm. at the aperture. From this it is evident that there is a slight lateral compression of the conch, which apparently is accentuated at the aperture. It is estimated that about 8 camerae occupied a length equal to the dorso-ventral diameter of the conch at the top of the series counted, when the counting is done along the ventral outline of the conch. The sutures of the septa rise slightly in a ventrad direction. The concavity of the septa is approximately 20 mm.

According to Foord, the siphuncle is large and cylindrical, with little or no inflation between the septa; its diameter is 14 mm., or 2/11 that of the longer diameter of the shell. It is excentric in position, and is situated about $\frac{3}{8}$ across the longer diameter, measuring from its center to the margin of the shell.

According to a sketch prepared by Mr. A. Reely of the British Museum of Natural History, for Dr. F. A. Bather, the siphuncle is 13 mm. wide where the dorsoventral diameter of the conch is 66 mm., and where the center of the siphuncle is 26 mm. from the ventral wall of the conch. The sides of the segments

of the siphuncle are straight and present no constrictions at the septa. Therefore, the specimen can not belong to *Monocyrtoceras.*

The surface of the shell is banded transversely, 8 bands occurring in a length of 40 mm. along the lower half of the living chamber, while almost 10 bands occur in an equal length along its upper half, where the conditions are more gerontic. The upper margin of these bands is elevated distinctly above the lower margin of the immediately overlying band. These bands curve faintly downward along the median parts of the ventral side, their total downward curvature equalling 2 or 3 mm. This is the nearest approach to a hyponomic sinus shown by the specimen described. In addition, the cast of the interior of the conch is marked by very low vertical ribs, of which some at least are visible also as low vertical ribs on the exterior surface of the shell.

Locality and Horizon.—Offley Island, Kennedy Channel, Arctic America; in Silurian strata of Niagaran age.

Remarks.—Until the structure of the siphuncle of *Monocyrtoceras arcticum* is more definitely known it will be impossible to be certain that it belongs to the genus *Monocyrtoceras*[48] which was founded on a series of specimens from the Racine of Wisconsin.

52. **Westenoceras** (?) **tumidum** (Schuchert)

Plate VIII, figs. 7 A, B

Oncoceras tumidum Schuchert, Proc. U. S. National Museum, 22, 172, pl. 14, figs. 1–3 (1900).

Specimen consisting of the lower part of the living chamber to which 5 camerae still are attached. All of this part of the conch contracts toward the aperture and is laterally compressed. The sutures of the septa curve downward distinctly laterally. The concavity of the septa equals about 7 mm. in a lateral direction. A dorso-ventral vertical section fails to show any trace of the siphuncle. When Schuchert studied the specimen he found some structure resembling a siphuncle situated about 6 mm. in-

[48] Aug. F. Foerste. Notes on American Paleozoic Cephalopods. Jour. Sci. Labs. Denison Univ., 20, 259, pls. 37–41 (1924).

side of the ventral wall. This suggests the possibility of the specimen being related to *Westenoceras* in which the ventral vertical outline is convex and the dorsal outline is concave along the upper part of the conch. Unfortunately the siphuncle of *Westenoceras* cannot be described as small.

Locality and Horizon.—From the head of Frobisher Bay, in Baffin Land; in strata regarded as Trenton, but possibly including also strata of Richmond age. Specimen No. 28190, in the U. S. National Museum.

Remarks.—The genotype of *Westenoceras*[49] was found in the Winnipeg limestone on various islands in the southern part of Lake Winnipeg. *Westenoceras latum* Troedsson[50] is cited from that part of the Cape Calhoun series which is regarded as Trenton.

53. **Diestoceras schucherti** Sp. nov.

Plate IX, figs. 2 A, B, C; pl. XXVII, figs. 4 A–D

Poterioceras sp., Schuchert, Proc. U. S. National Museum, 22, 173 (1900).

Specimen short, 40 mm. in length, enlarging rapidly along the phragmacone, and contracting rapidly along the living chamber. The ventral side of the living chamber is more evenly convex, and the upper half of its dorsal side is slightly flattened. The aperture is open, without any trace of a hyponomic sinus. The camerae, as far as preserved, are short. Several camerae appear to be missing between the uppermost camerae and the two preserved farther down. The siphuncle is relatively large, its diameter equalling almost one-fourth of that of the conch at the top of the phragmacone. It is located close to the ventral side of the conch, but not in actual contact with the latter. The concavity of the septum at the base of the specimen gives this base a rounded appearance.

[49] Cyrtoceras manitobense, Whiteaves, in Trans. Royal Soc. Canada, 7, sec. 4, pl. 13, figs. 3–5; pl. 15, fig. 4 (1890).

[50] Gustaf Troedsson. On the Middle and Upper Ordovician Faunas of Northern Greenland, pt. 1, Cephalopods, 90, pl. 54, figs. 2, 3 (1926).

Locality and Horizon.—From the head of Frobisher Bay, in Baffin Land; from strata regarded as of Trenton age, but possibly including also some Richmond. Troedsson described one species of *Diestoceras* from the Richmond part of the Cape Calhoun series. Species occur in the Richmond also of Anticosti, Ohio, and Indiana. In southern Manitoba, species of *Diestoceras* occur both in the upper and lower parts of the Winnipeg limestone. It is with this Winnipeg limestone that the Frobisher Bay horizon in which *Diestoceras schucherti* and *Charactoceras* occur is correlated provisionally. The Frobisher Bay specimen is numbered 28122 in the U. S. National Museum.

54. **Manticoceras pattersoni** (Hall)

Plate XXI, figs. 2 A–E

Manticoceras Pattersoni Clarke, The Naples Fauna (Fauna with *Manticoceras intumescens*) in western New York; New York State Museum, 50th Annual Report of the Regents for 1896, 45–62, pl. 1, figs. 1–12; pl. 2, figs. 1–4; pl. 4, figs. 14–18; text figures 1–28 (1899). Part 2 of this report on the Naples Fauna forms memoir 6 of the New York State Museum, published in 1904.

Four fragments of *Manticoceras*, evidently closely related to *Manticoceras pattersoni* (Hall), were found by Savage and Van-Tuyl in the upper 8 feet of their Abitibi limestone section, as exposed at the Long Rapids of that river in the area south of James Bay. This horizon is numbered 11 in their published section. Compared with typical *Manticoceras pattersoni*, these Abitibi River specimens are relatively small, and there is a possibility that complete specimens might prove distinguishable from the typical New York specimens of *Manticoceras pattersoni* in other respects than mere size; however, there is no doubt of the close relationship of the two. The chief interest in these Abitibi specimens is due to the fact that they, as well as the New York specimens, belong to an Eurasian fauna of wide distribution and of considerable interest.

In Europe, a slightly more progressive stage of *Manticoceras pattersoni* is known as *Manticoceras intumescens*. There this *Manticoceras intumescens* is associated with *Buchiola retriostriata* and is underlaid by a horizon containing *Hypothyridina cuboides* and *Pugnax pugnus*, though the *Pugnax* is known also from higher horizons. A somewhat similar arrangement is noted in New York where *Manticoeras pattersoni* associated with *Buchiola retriostriata* occurs in the Naples phase of the Portage group, while *Hypothyridina cuboides* occurs in the Tulley limestone beneath, and *Pugnax pugnus* ranges as far up as the Chemung.[51]

In 1916 Prof. T. E. Savage and F. M. VanTuyl found specimens closely allied to if not identical with *Manticoceras pattersoni* at the Long Rapids of the Abitibi River, south of James Bay, in the upper 8 feet of their Abitibi River limestone, forming zone 11 of their section along this river.[52] Later, Prof. M. Y. Williams found *Hypothyridina cuboides* at the Long Rapids in a bed of greenish limestone 2 feet thick which seems to belong at the top of the Abitibi River limestone as originally defined by Savage and VanTuyl.[53] Both are Upper Devonian species, but the presence of the *Hypothyridina* suggests that the horizon is low in the Upper Devonian.

A similar low horizon is indicated by the presence of *Hypothyridina cuboides* and *Pugnax pugnus* on the Mattagami River, which also is south of James Bay.[53]

The *Buchiola retriostriata*, which is associated with *Manticoceras intumescens* in European faunas, is identical with the *Buchiola speciosa* associated with *Manticoceras pattersoni* in the Portage fauna of New York. This *Buchiola* occurs not only in New York, but extends along the Appalachians from central Pennsylvania to southwest Virginia. In 1917 Dr. E. M. Kindle found this species, associated with others belonging to the Portage fauna

[51] John M. Clarke. The Naples Fauna in western New York, pt. 2 (cited above), 350–360, 382 (1904).

[52] T. E. Savage and F. M. Van Tuyl. Geology and Stratigraphy of the area of Paleozoic Rocks in the vicinity of Hudson and James Bays. Bull. Geol. Soc. America, 30, 373 (1919).

[53] E. M. Kindle. Geology of a Portion of the Northern Part of Moose River Basin, Ontario, Geol. Surv. Canada, Summary Rept., 1923, part CI, 36C I (1924).

of New York, on the Mackenzie River, below Simpson, in the region west of Great Slave Lake.[54]

The *Manticoceras* figured by Whiteaves, from 40 miles above the entrance of the Hay River into Great Slave Lake, appears to have been associated with *Spirifer disjunctus* at a horizon approximately equivalent to the Chemung of New York.[55]

In Europe *Manticoceras intumescens* ranges from South Devon in Great Britian to Belgium, Germany, Poland, the Timan Range in northern Russia, and both the east and west sides of the Ural Mountains. In North America *Manticoceras pattersoni* ranges from the Great Slave Lake and James Bay areas to the western part of New York, though the connecting areas are unknown. Judging from progressive stages of development of the septal structure of species of *Manticoceras* in different areas, Clarke was of the opinion that the direction of migration of the *Manticoceras* fauna was from the Timan area eastward to New York, and thence to western Europe.[56] In New York, this *Manticoceras* fauna is known only from the western part of the state, in what Clarke called the Genesee province. *Manticoceras pattersoni* is found only in the eastern or Naples phase of this Genesee province. This *Manticoceras* fauna is a foreign element, being introduced abruptly, and having no connection with preceding faunas. The fauna of the middle or Ithaca province of New York, during Portage times, however, was a direct development of the preceding Hamilton fauna, with increasing divergence from the latter at successively later stages of growth. The eastern or Oneonta province was covered by fresh or estuarine waters.[57]

The Ithaca phase of the *Buchiola retriostriata* fauna of the Portage in New York occurs along the lower Peace River in northern Alberta.[58]

[54] E. M. Kindle. The Discovery of a Portage Fauna in the Mackenzie River Valley. Geol. Surv. Canada, Mus. Bull. 29, 2–4 (1919).

[55] J. F. Whiteaves. The fossils of the Devonian Rocks of the Mackenzie River Basin. Geol. Surv. Canada. Contributions to Canadian Paleontology, 1, pt. 3, no. 5, 245, pl. 31, fig. 5 (1891).

[56] John M. Clarke. The Naples Fauna in Western New York, pt. 2 (cited above), 384, also pl. A, facing p. 208 (1904).

[57] Ibidem, 209–211; also pl. B, facing p. 210.

[58] E. M. Kindle. The Occurrence and Correlation of a Devonian Fauna from Peace River, Alberta. Geol. Surv. Canada. Contrib. to Can. Pal., Bull. No. 49. 14–18 (1927).

A NEW GENUS AMONG THE CONULARIDAE

METACONULARIA Gen. nov.

Genotype: *Conularia aspersa* Lindström. On the Silurian Gasteropoda and Pteropoda of Gotland, Kongl. Svensk. Vetensk. Akad. Handl., 19, no. 6, 45, pl. 1, figs. 4–8 (1884); also The British Conulariae, by Ida L. Slater, in Palaenotographical Society of London, vol. 20, pl. 1, figs. 5–9 (1907).

Shell similar to typical *Conularia* in form, but very thin, its surface ornamented by very minute granules or papillae, usually too small to be distinguishable readily with the unassisted eye. These granules are arranged in numerous transverse and vertical rows. Each of the four faces of the shell is supplied on its interior with two vertical septa which are close to the median line of the face. These septa are very thin, and project inward only for a very short distance, often only about half a millimeter or less. Frequently the location of these septa can be determined through the very thin shell in the form of two very narrow vertical lines, more or less distinctly darker than the remainder of the shell, at a moderate distance from one another, one on each side of the median line of each face of the shell.

Two species of *Conularia* having these characteristics were described by Lindström in the publication cited above; namely *Conularia bilineata* and *Conularia aspersa*. The type of *Conularia aspersa* was obtained in the *Pterygotus* horizon of the Gotlandian near Wisby, and is preserved in the Vetenskaps Akademi, at Stockholm. Specimens regarded as identical with *Conularia aspersa* have been described by Ida Slater from the Lower Ludlow shales at Church Hill, Leintwardine, Bow Bridge, and other localities in Breat Britian. These British specimens are here selected as the genotype of *Metaconularia*. In these British specimens the transverse ridges arch gently across each face. The septa are 3 mm. apart at the top of the specimens but converge to 0.25 mm. at their apex. Along the exterior of the shell the location of these septa is indicated by vertical black lines. Figure 6a published by Ida Slater illustrates a part of the shell showing the septa, magnified 5 diameters.

At the end of his original description of *Conularia aspersa*, Lindström stated that "Among coeval species the Bohemian *Conularia munita* is somewhat resembling." Dr. E. O. Ulrich informs me that a species of *Metaconularia* occurs in Bohemia at the Ordovician horizon D4–2, associated with *Cyclopyge* (*Aeglina*) and *Placoparia*.

Two species of *Metaconularia* were described by Hall (Pal. New York, 1, 223, pl. 59 (1847)), namely *Conularia granulata* and *Conularia papillata* from the Trenton at Middleville, New York. At Harvard college there are two specimens of *Metaconularia* labelled *Conularia papillata*, both from the Trenton of Trenton Falls, New York. These are numbered 27810 and 27809 respectively, and each is illustrated on plate 29 of the present publication by a view of part of its surface, magnified 12 diameters. They evidently belong to two distinct species.

Of these, the larger specimen (pl. 29, fig. 1) is 250 mm. long and shows all four sides, but is depressed laterally to a thickness of 25 to 30 mm. Two of the four faces are well preserved, considering the large size of the specimen, but the alternate two faces are much narrowed by pressure, though unbroken. The shell apparently consisted of some tough chitinous material that bent and wrinkled, but did not break readily. One of the faces enlarged from a width of 62 to 89 mm. in a length of 160 mm. The opposite face enlarged from 68 mm. to 84 mm. in a length of 142 mm. This indicates an apical angle of only 4.5 degrees, and suggests that the original length of the shell was probably at least 500 mm. The 4 angles of the shell were occupied each by an impressed groove, but this groove appears to have been shallow, and it left but a poor trace of its original presence in the fossilized shell. Apparently the width of this impressed groove did not exceed 5 mm., and the groove was distinctly defined only along the median line of the impressed area. Along the middle of each face there is a distinct narrow groove, not over half a millimeter in width, on each side of which there is an additional impressed groove, probably locating the position of a septum in the interior of the shell. These additional impressed grooves are 6 mm. apart at the smaller end of the specimen, and 9 mm. apart at its

larger end. The surface of the shell is marked by minute papillae arranged in vertical and transverse rows crossing each other at right angles. Of the vertical rows there usually are 6 in a width of 1 mm., though their number may be 8 locally. Of the horizontal rows there usually are 5 in a length of 1 mm. The general surface of the specimen is flat, and not raised into distinct transverse ridges alternating with grooves, as in typical *Conularia*.

In the second specimen, numbered 27809, both the vertical and the transverse rows of papillae are more numerous, and the papillae tend to be elongated in a vertical direction. A part of the surface of this specimen is illustrated, enlarged 12 diameters, by fig. 2 on pl. 29 of this bulletin.

Another relatively large specimen was found by Dr. E. O. Ulrich in the upper layers of the Platteville limestone near Platteville, Wisconsin. A small part of its surface, also enlarged 12 diameters, is illustrated by fig. 3 on plate 29. This species is characterized by the very small size of its granules and their great number. For it the name *Metaconularia ulrichi* here is proposed. A more detailed description will follow.

Another species of *Metaconularia* is the form described by Savage as *Conularia delicatula* (Illinois Acad. Sci., 270, pl. 1, fig. 10 (1907)) from the lower part of the Thebes sandstone, in the vicinity of Thebes, Illinois. This Thebes sandstone is correlated by Ulrich and Bassler with the Maquoketa of Iowa, in Bassler's Index of American Ordovician and Silurian Fossils. In the type of *Conularia delicatula* only one face is exposed, and this enlarges approximately at an angle of 20 degrees. Its median part is traversed by two vertical blackish lines, contrasting with the brownish color of the remainder of the shell. At the base of the specimen they are 1.75 mm. apart, separating to 2.75 mm. at a point 40 mm. farther up. The width of these lines varies from one-sixth of a millimeter at the base to one-fourth at the top of the specimen. Along the lower half of the specimen these lines are faintly grooved along the middle. At one point, near the base of the specimen, it is seen that each vertical line is followed along the inner surface of the shell by a sharp vertical striation or

septum which extends inward scarcely one-fourth of a millimeter. The exterior surface of the shell is crossed by numerous fine transverse wrinkles and by still finer transverse striae, the latter being visible only under a lens. These striae are nearly straight laterally but curve in crossing the median part of the face of the shell. Usually there are about 20 transverse striae in a length of 1 mm., but locally there may be only 16. The crests of the striae are lined with a row of very minute papillae, from 20 to 25 in a width of 1 mm. These papillae are arranged in vertical rows, so that the surface of the shell appears minutely striated both vertically and horizontally. The distance between the vertical rows usually is slightly less than that between the transverse rows, but locally they may be equal in number.

Conularia heymanni Foerste (Jour. Sci. Labs. Denison Univ., 19, 208, pl. 21, fig. 12; pl. 22, fig. 12 (1920)), from the top of the Plattin limestone in Ralls county, in northeastern Missouri, agrees with typical *Metaconularia* in having the two median septa on the interior of each face of the shell, and in the minuteness of the granules or papillae ornamenting the shell, but the transverse striae bearing these granules are separated by grooves which are conspicuously broader than the striae, thus producing a different appearance.

The unnamed *Conularia* described and figured in the same publication (p. 210, pl. 21, fig. 9; pl. 22, figs. 9 A, B), also from the upper part of the Plattin limestone in Ralls county, Missouri, probably is a *Metaconularia*.

It is not intended to include in *Metaconularia* those species in which there is only a single septum along the median line of each face, as in *Conularia tenuis*, and *Conularia maculosa*, both described by Ida Slater in the publication cited above. For these a separate term should be proposed, but no specimens of this type have come under my own observation.

PLATES

PLATE I

Fig. 1. *Cyclendoceras boreale* Foerste. A, lateral view, with ventral outline on left; B, natural exposure of siphuncle in dorso-ventral section of conch, with ventral outline on right. Port Burwell, west of Cape Chidley, at north end of Labrador; in Black River limestone. Specimen in two fragments numbered 7922 and 7924 in Victoria Memorial Museum. See also pl. 22, figs. 2A, 2B.

X 0.9

1A

X0.88

1B

PLATE II

Fig. 1. *Endoceras chidleyense* Foerste. Ventral view, exposing the siphuncle near the base of the specimen. Port Burwell, west of Cape Chidley, at northern end of Labrador; in the Black River limestone. Specimen No. 7925 in the Victoria Memorial Museum. See also pl. 22, figs. 1A, 1B.

Fig. 2. *Eurystomites chidleyense* Foerste. A, ventral view of that part of the conch which in the figure on plate 20 is included between the fractures 2 and 4, showing fracture 3 at mid-height. B, dorsal view of another fragment of same specimen, between fractures 4 and 6. C, central part of same specimen, up to fracture 6, but from side of specimen opposite to that represented on plate 20. Port Burwell, west of Cape Chidley, at north end of Labrador; in the Black River limestone. Specimen No. 7932 in the Victoria Memorial Museum. See also pl. 20, and pl. 27, figs. 2 A–F.

1

X 0.8

2A

X 0.83

2B

X 0.83

X 0.83

2C

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PLATE III

Fig. 1. *Cyclendoceras annulatum* (Hall). Dorso-ventral section through the type of the species, exposing the siphuncle and an endocone. Watertown, New York; in the Trenton limestone. Specimen No. 811 in the American Museum of Natural History. See also Jour. Sci. Labs. Denison Univ., 19, 299, pl. 31, fig. 3 (1921).

Fig. 2. *Plectoceras occidentale* (Hall). Ventral view of specimen illustrated on pl. 17, illuminated from upper right-hand corner, and showing the downward curvature of the transverse ribs. Homer, in Troy Grove township, in LaSalle county, Illinois; in the Black River formation. Specimen No. 1002–5 in the American Museum of Natural History. See also pl. 26, fig. 1.

X0.85

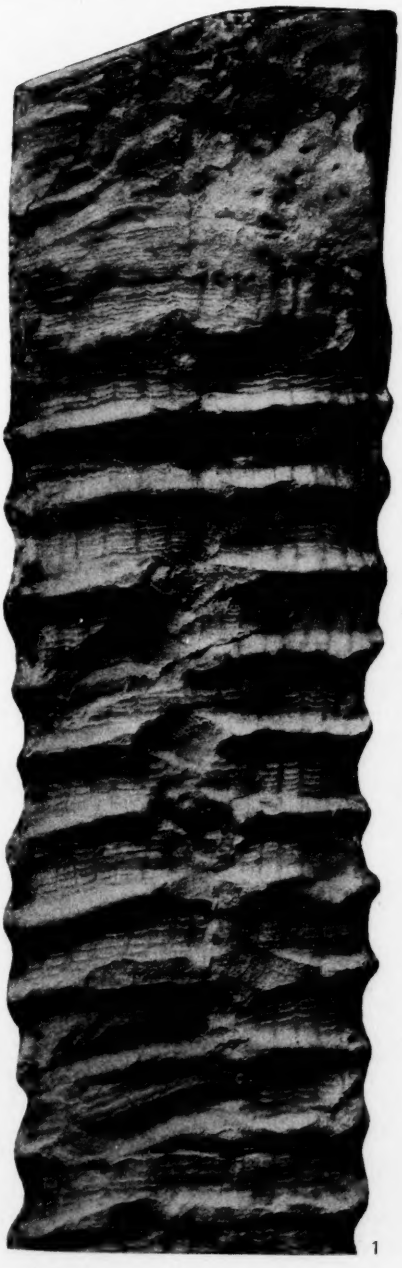
1

X0.85 2

PLATE IV

Fig. 1. *Dawsonoceras granti* Foerste. Lateral view, ommitting 23 mm. of the length of the specimen at its base. Niagara Falls, Ontario; in the Barton division of the Lockport. Specimen No. 2644 in the Redpath Museum of McGill University. See also pl. XXVIII, fig. 5 A, B.

Fig. 2. *Dawsonoceras hyatti* Foerste. Lateral view of specimen retaining the surface of the shell. Hamilton, Ontario; in the Niagaran, presumably in the Lockport. Specimen No. 2648 in Redpath Museum at McGill University. Genotype of *Dawsonoceras*. See also pl. XXVIII, fig. 6.



1

2

PLATE V

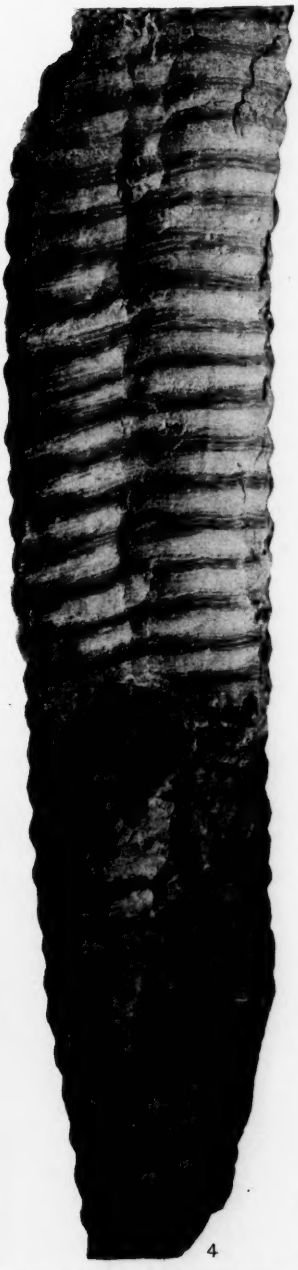
Fig. 1. *Dawsonoceras annulatum* (Sowerby). A, lateral view; B, part of same specimen enlarged 2.6 diameters in order to show character of transverse striae. These are much more numerous on the annulations than in the intermediate grooves. Coalbrookdale, Shropshire, England; from the Wenlock division of the Silurian. Specimen No. 43839 in the British Museum of Natural History.

Figs. 2, 3. *Dawsonoceras americanum* (Foord). Lateral views of two specimens showing the surface ornamentation. Ripley county, Indiana; from upper part of Osgood member of the Niagaran division of the Silurian. Specimens numbered 67061 in the U. S. National Museum.

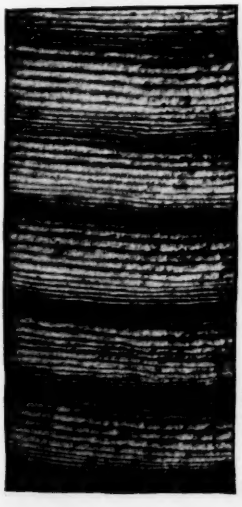
Fig. 4. *Dawsonoceras americanum* (Foord). Lateral view, illuminated from the lower right-hand side, and therefore appears more natural when examined in an inverted position. The long festoons characteristic of this species are presented best by the lower part of the specimen. Along the greater part of its length, the transverse striae are nearly straight. Lockport, New York; in the Rochester shale member of the Niagaran division of the Silurian. Specimen No. 10400 in the U. S. National Museum.

1A

2



4



X 2.6

1B

3

PLATE VI

Fig. 1. *Monocyrtoceras* (?) *arcticum* (Foord). Lateral view, with ventral outline on right. The cast of the interior of the conch is ornamented by relatively distant transverse and longitudinal markings which correspond to similar, but more distinct, markings on the surface of the shell. Offley Island, Kennedy Channel, Arctic America; presumably from the Niagaran division of the Silurian. Specimen No. 89169 in the British Museum of Natural History.

Fig. 2. *Troedssonoceras turbidum* (Hall and Whitfield). Lateral view; the curvature of the sutures of the septa apparently is due to distortion. Coral reef in bank of Cumberland River at Rowena, Kentucky; in Fairmount or Leipers member of the Maysville formation, in the Cincinnatian series of the Ordovician. Specimen in the collection of Prof. W. H. Shideler, at Miami University. See also pl. 23, fig. 9.

Fig. 3. *Kochoceras foordi*, Foerste. Dorsal view of weathered specimen; its basal part is formed by one segment of the siphuncle with the septal neck at its lower end; above this segment are exposed the dorsal margin of two additional segments. Igloolik Island, Fox Channel, Arctic America; probably of Richmond age. Specimen No. 33452 in the British Museum of Natural History.

Fig. 4. *Dawsonoceras crassum* (Foord). Transverse striae. Figure copied from Catalogue of the Fossil Cephalopoda in the British Museum (Natural History), pt. 1, 1888, p. 53, fig. 4b. Occurring in the Wenlock, Aymestry, and Upper Ludlow limestones of the Silurian of England.

Fig. 5. *Dawsonoceras subtile* (Foord). Transverse striae. Figure copied from Catalogue cited above, p. 53, fig. 4e. Occurring in the Wenlock shales and Upper Ludlow of Great Britain.

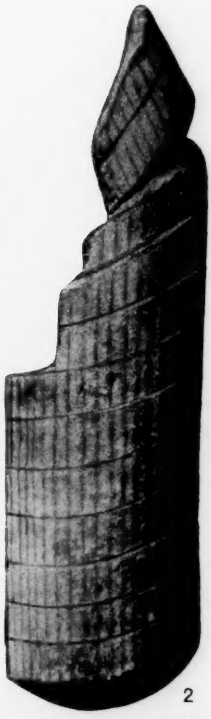


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PLATE VII

Fig. 1. *Kionoceras scalariforme* (Schuchert). Lateral view, enlarged 2.2 diameters. Frobisher Bay, Baffin Land; Trenton, or possibly Richmond. Specimen No. 28195 in U. S. National Museum.

Fig. 2. *Spyroceras porteri* (Schuchert). A, lateral view, enlarged 2.2 diameters; B, same, natural size. Frobisher Bay, Baffin Land; Trenton, or possibly Richmond. Specimen No. 28194 in U. S. National Museum. See also pl. 23, fig. 4.

Fig. 3. *Actinoceras sp.* Dorsal side of strongly weathered specimen. Bering Strait, Alaska; presumably of Black River or Trenton age. Specimen in U. S. National Museum. See also pl. XXVIII, fig. 3.

Fig. 4. *Orthoceras moniliforme* Haughton. Specimen weathered so as to expose the moniliform siphuncle. Figure copied from Haughton in Journ. Royal Dublin Soc., 3, 1860, p. 57, pl. 1, fig. 5. Specimen from Cape Riley, in North Devon, Arctic America; from so-called Chazyan limestone. Regarded by Troedsson as possibly identical with *Eskimoceras boreale* (On the Middle and Upper Ordovician Faunas of Northern Greenland; I, Cephalopods, 82 (1926)).

Fig. 5. *Endoceras baffinense* Foerste. Ventral Side, exposing the siphuncle at its base. Frobisher Bay, Baffin Land; Trenton, or possibly Richmond. Specimen No. 28191 in U. S. National Museum.

Figs. 6, 7. *Ormoceras sp.* 6, ventral view, exposing one globular segment of the siphuncle; 7, upper view of a fragment showing size of passage of siphuncle through the septum. Frobisher Bay, Baffin Land; Trenton, or possibly Richmond. Specimens in U. S. National Museum.

Fig. 8. *Ephippiorthoceras baffinense* Foerste. Lateral view, exposing one segment of the siphuncle at its base. Frobisher Bay, Baffin Land; Trenton, or possibly Richmond. Specimen No. 33288B in U. S. National Museum.

Fig. 9. *Ephippiorthoceras compressum* Foerste. Lateral view, exposing one segment of the siphuncle at its base. Frobisher Bay; Trenton, or possibly Richmond. Specimen No. 38288A in U. S. National Museum. See also pl. 23, fig. 6.


1


2A


3


2B


5


4


8


7


6


9

PLATE VIII

Fig. 1. *Beloitoceras* (?) *baffinense* (Schuchert). Lateral view; specimen distorted at top. Frobisher Bay; Baffin Land; Trenton, or possibly Richmond. Specimen No. 28198 in U. S. National Museum. See also pl. 23, fig. 3.

Figs. 2–5. *Thuleoceras ornatum* Troedsson. 2, 3A, 4, lateral views; 3B, ventral view of 3A; 5, specimen viewed from above, showing location of siphuncle. Frobisher Bay, Baffin Land; Trenton, or possibly Richmond. Specimens No. 28119 in U. S. National Museum. See also pl. 23, fig. 8.

Fig. 6. *Beloitoceras arcticum* (Schuchert). A, ventral view, showing siphuncle; B, lateral view with ventral outline on left. Both figures restored at apical end. Frobisher Bay, Baffin Land; Trenton, or possibly Richmond. Specimen No. 28196 in U. S. National Museum. See also pl. 23, fig. 5.

Fig. 7. *Westenoceras* (?) *tumidum* (Schuchert). A, dorsal view; B, lateral view, with ventral outline on left. Frobisher Bay, Baffin Land; Trenton, or possibly Richmond. Specimen No. 28190 in U. S. National Museum.

Fig. 8. *Beloitoceras* (?) *cornulum* (Schuchert). A, lateral view, with ventral outline on right; B, dorsal view. Frobisher Bay, Baffin Land; Trenton, or possibly Richmond. Specimen No. 28121 in U. S. National Museum. See also pl. 23, fig. 7.


1
2
3A
3B
4
5
6A
6B
7A
7B
8A
8B

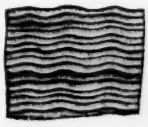
PLATE IX

Fig. 1. *Diestoceras schucherti* Foerste. A, lateral view, with siphuncle on left; B, basal view, with siphuncle on lower margin of figure; C, ventral view, showing siphuncle along median line; D, viewed from above, showing outline of aperture, with ventral side forming its lower margin. Frobisher Bay, Baffin Land; Trenton, or possibly Richmond. Specimen No. 28122, in U. S. National Museum.

Fig. 2. *Charactoceras schucherti* Foerste. A, lateral view, with missing part of phragmacone restored; B, ventral view of upper part of specimen; C, dorsal view of latter, inverted so as to place the upper end of the specimen at the base of the figure; showing dorsal impressed zone; also location of siphuncle. Frobisher Bay, Baffin Land; Trenton, or possibly Richmond. Specimen No. 28123 in U. S. National Museum. See also pl. 27, figs. 4 A–D.

Fig. 3. *Dawsonoceras americanum* (Foord). Part of the surface of natural size; showing the festoons formed by the transverse striae. The figure does not indicate the transverse annulations clearly, but is the original figure presented by Foord in his Catalogue of the Fossil Cephalopoda in the British Museum, page 53, fig. 4c (1888). According to Dr. A. F. Bather, this figure illustrates equally well the specimen from Lockport, New York, and that from Ripley county, Indiana, mentioned by Foord in his original description.

1A



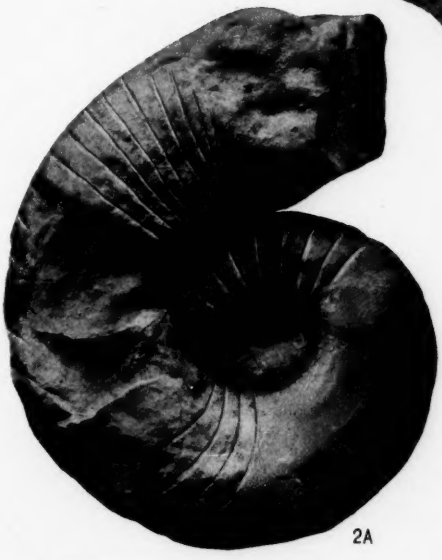
3

1C

1B

2C

1D



2A

2B

PLATE X

Fig. 1. *Huronia occidentale* Foerste. A, ventral view, showing contact areas of ventral side of segments of the siphuncle with the ventral wall of the conch; B, Lateral view, with ventral outline on right, the dorsal outline of the segments of the siphuncle forming the left margin of the figure. Mocassin Mountain, Big Horn Range, Wyoming; from the Richmond. Specimen in U. S. National Museum.

Fig. 2. *Huronia occidentale* Foerste. Fragment of the siphuncle, with ventral outline on right. Mouth of Red River, at southern end of Lake Winnipeg, in southern Manitoba. Specimen No. 4762 in U. S. National Museum.

Fig. 3. *Kionoceras* cf. *myrice* (Hall and Whitfield). Lateral view, Offley Island, Kennedy Channel, Arctic America; from Niagaran division of the Silurian.


1A
1B
2
3

PLATE XI

Fig. 1. *Cyclendoceras sp.* Lateral view with ventral side on left. Mount Beaufort, south of northwest corner of Grinnell Land, the northwestern extension of North Devon Island; apparently erratic from some Black River or Trenton source. Specimen No. 96964 in the British Museum of Natural History. See also pl. 22, fig. 4.

Fig. 2. *Kochoceras feildeni* Foerste. Lateral view of specimen represented in Jour. Sci. Labs. Denison Univ., 22, by figs. 1 A-C on pl. 10 (1927); showing part of segment of siphuncle at its base. Cape Louis Napoleon, west of Kane Basin, Arctic America; possibly from the Richmond. Specimen No. 89179 in the British Museum of Natural History. See also pl. 25, figs. 2 A, B.

Fig. 3. *Kochoceras lenticulare* Foerste. Dorsal side of specimen, showing dorsal side of segments of the siphuncle. Same specimen as that represented in Jour. Sci. Labs. Denison Univ., 22, by fig. 1 on pl. 7 (1927). Probably from some locality between Dobbin and Scoresby Bay, west side of Kennedy Channel, Arctic America; presumably from the Richmond. See also pl. 25, figs. 1 A, B.

Fig. 4. *Sactoceras sp.* Lateral view. Griffith Island, south of Cornwallis Island, Arctic America; in strata recorded as Silurian. Specimen No. C 2126b in the British Museum of Natural History. See also pl. 22, figs. 3 A, B.

Fig. 5. *Orthoceras ommaneyi* as identified by Haughton in Journ. Royal Dublin Soc., 1, p. 249, pl. 11, fig. 5 (1857), of which the present figure is a copy. A vertical dorso-ventral section through the siphuncle, apparently of some cyrtoceroid. Assistance Bay, Cornwallis Island, Arctic America. The present location of this specimen is not known.

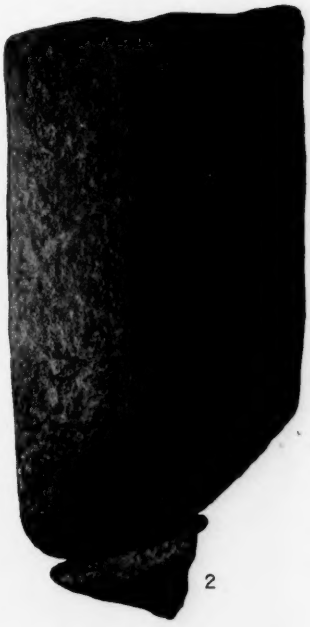


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PLATE XII

Fig. 1. *Armenoceras coppingeri* Foerste. Weathered vertical section through the conch in a lateral direction, exposing the septa. Dobbin Bay, on western side of Kennedy Channel, Arctic America; in strata recorded as Silurian. Specimen No. C 2714 in the British Museum of Natural History. See also pl. 24, figs. 4 A, B.

Fig. 2. *Armenoceras* (?) *sp.* Lateral view. Cape Napoleon, northwest of Kane Basin; presumably from the Ordovician. Specimen C 2716 in the British Museum of Natural History. See also pl. 24, fig. 5.

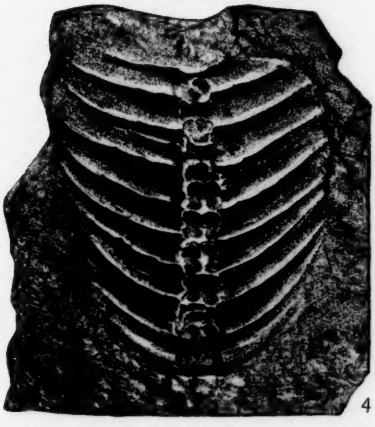
Fig. 3. *Armenoceras sp.* Left ventro-lateral side of the conch, with matrix still attached. Dobbin Bay, on western side of Kennedy Channel, Arctic America; presumably from the Silurian. Specimen No. C 2715 in the British Museum of Natural History. See also pl. 23, figs. 2 A, B, C.

Fig. 4. *Ormoceras crebriseptum* as identified by Haughton from grey earthy limestone on west shore of King William Land, in Journ. Royal Dublin Soc., pl. 1, fig. 3 (1860), of which the present figure is a copy. Natural vertical section through the siphuncle. The present location of this specimen is unknown. It is assumed to be of Ordovician age.

1

2

3



4

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PLATE XIII

Fig. 1. *Armenoceras naresi* Foerste. Ventral view. Arctic America; probably from the Silurian. Specimen No. 82680 in the British Museum of Natural History. See also pl. 23, figs. 1 A, B, C, D.

Fig. 2. *Armenoceras lyoni* (Stokes). Ventral view, with ventral margin of most of the segments of the sub-central siphuncle. Igloolik Island, Fox Channel, Arctic America; possibly from the Richmond. Specimen No. 34046 in the British Museum of Natural History. See also pl. 14, fig. 1, and pl. 24, fig. 1 A, B.

Figs. 3, 4. *Armenoceras* (?) *ommaneyi* (Salter), 3, septum viewed from beneath, showing passage of siphuncle; here regarded as type of species; 4, assumed by Salter to be a smaller specimen of the same species. Assistance Bay, Cornwallis Island, Arctic America; from strata recorded as Silurian. Both of the figured specimens appear to be lost. Copied from Sutherland's Jour. Voyage in Baffin Bay, etc., 222, pl. 5, figs. 17, 16 (1852).

Fig. 5. *Armenoceras* cf. *ommaneyi* (Salter). A, ventral view; B, lateral view, with ventral outline on left. Assistance Bay, Cornwallis Island; from strata recorded as Silurian. Specimen No. 96954 in the British Museum of Natural History. See also pl. 24, figs. 2 A, B. C.

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AMERICAN ARCTIC AND RELATED CEPHALOPODS

PLATE XIV

Fig. 1. *Armenoceras lyoni* (Stokes). Natural vertical section through center of the sub-central siphuncle in a lateral direction, taken from a cast of the type. Igloolik Island; Fox channel, Arctic America; probably from the Richmond. Specimen No. 34046 in the British Museum of Natural History. See also pl. 13, fig. 2, and pl. 24, figs. 1A, B.

Fig. 2. *Huronia vertebralis* as identified by Haughton in Jour. Royal Dublin Soc., 3, 57, pl. 2, figs. 1, 2 (1860). Part of siphuncle, weathered at top and bottom so as to show the endosiphuncle. West side of King William Land; from compact cream colored chalky dolomite, assumed to be of Silurian age, but compared by Troedsson with *Huronia arctica* from the Richmond of Cape Calhoun.

Fig. 3. *Amphicyrtoceras darwini* (Billings). A, lateral view with ventral outline on right, upper left part restored; B, ventral view, with upper right part restored. Type, from New Hope, now Hespeler, Ontario, Canada; in the Guelph dolomite, Silurian. Specimen numbered 2924 in Victoria Memorial Museum.

Fig. 4. *Orthoceras griffithi* Haughton. Section through the siphuncle. Griffith Island, south of Cornwallis Island, Arctic America; recorded as from the Silurian. Copied from Journ. Royal Dublin Soc., 1, pl. 5, fig. 1 (1857).

1

2

3A

4

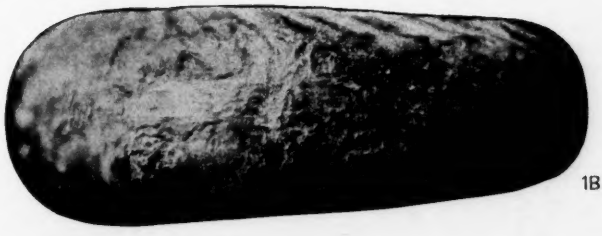
3B

PLATE XV

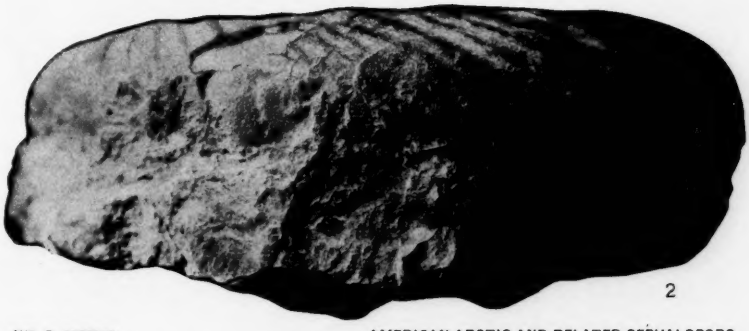
Fig. 1. *Plectoceras undatum* (Conrad). A, lateral view; B, ventral view. Watertown, New York; in the Black River limestone. Specimen No. 829–1 in the American Museum of Natural History. Same specimen as Pal. New York, 1, pl. 13, fig. 1 (1847). See also pl. 26, fig. 4.

Fig. 2. *Plectoceras undatum* (Conrad). Ventral view of same specimen as that represented by pl. 16, fig. 1. Watertown, New York; in the Black River limestone. Specimen No. 639a in the American Museum of Natural History. See also pl. 26, fig. 3.

1A



1B



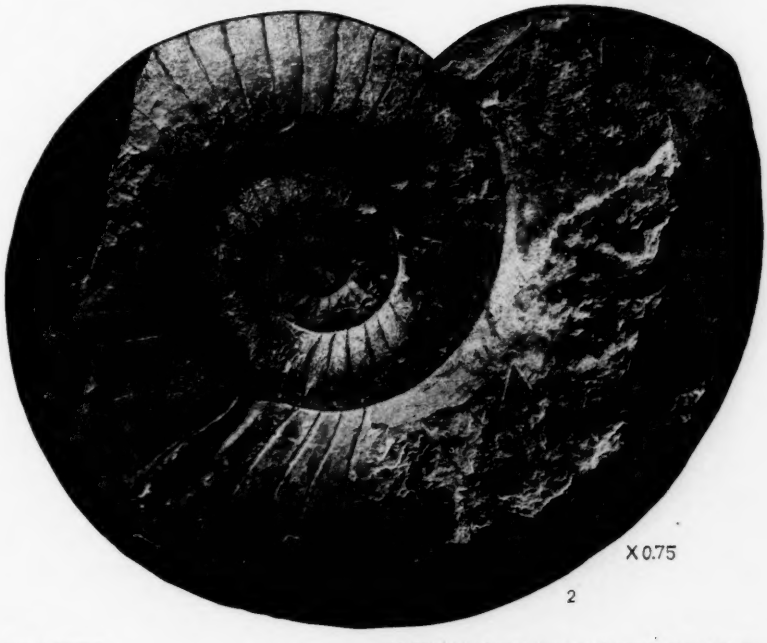
2

PLATE XVI

Fig. 1. *Plectoceras undatum* (Conrad). Lateral view of conch retaining part of the living chamber, and showing the great thickness of the shell along the dorsal side of this chamber. Watertown, New York; in the Black River limestone. Specimen No. 609a in the American Museum of Natural History. Same specimen as Pal. New York, 1, pl. 13 bis, Fig. 1 (1847). See also pl. 15, fig. 2, and pl. 26, fig. 3.

Fig. 2. *Eurystomites kelloggi* (Whitfield). Lateral view. Fort Cassin, Vermont; in the Fort Cassin member of the Beekmantown, of Upper Canadian age. Specimen No. 490A in the American Museum of Natural History; type of species. Same specimen as Bull. Amer. Mus. Nat. Hist., 1, pl. 30, fig. 1 (1886). See also pl. 27, fig. 1.

1



2

PLATE XVII

Fig. 1. *Plectoceras occidentale* (Hall). Lateral view, showing the great thickness of the shell. Homer, Troy Grove township, LaSalle county, Illinois; in the Black River limestone. Specimen No. 1002–5 in the American Museum of Natural History. See also pls. 3, fig. 2, and pl. 26, fig. 1. Same specimen as Mem. Amer. Mus. Nat. Hist., 1, pt. 2, pl. 11, fig. 1; pl. 12, fig. 3 (1895).


X0.8
1

PLATE XVIII

Fig. 1. *Plectoceras lowi* Foerste. Lateral view, specimen considerably incrusted with lime. Port Burwell, west of Cape Chidley, in northern Labrador; in erratic boulders of Black River limestone. Specimen No. 7929 in the Victoria Memorial Museum. See also pl. 19, and pl. 26, fig. 2.

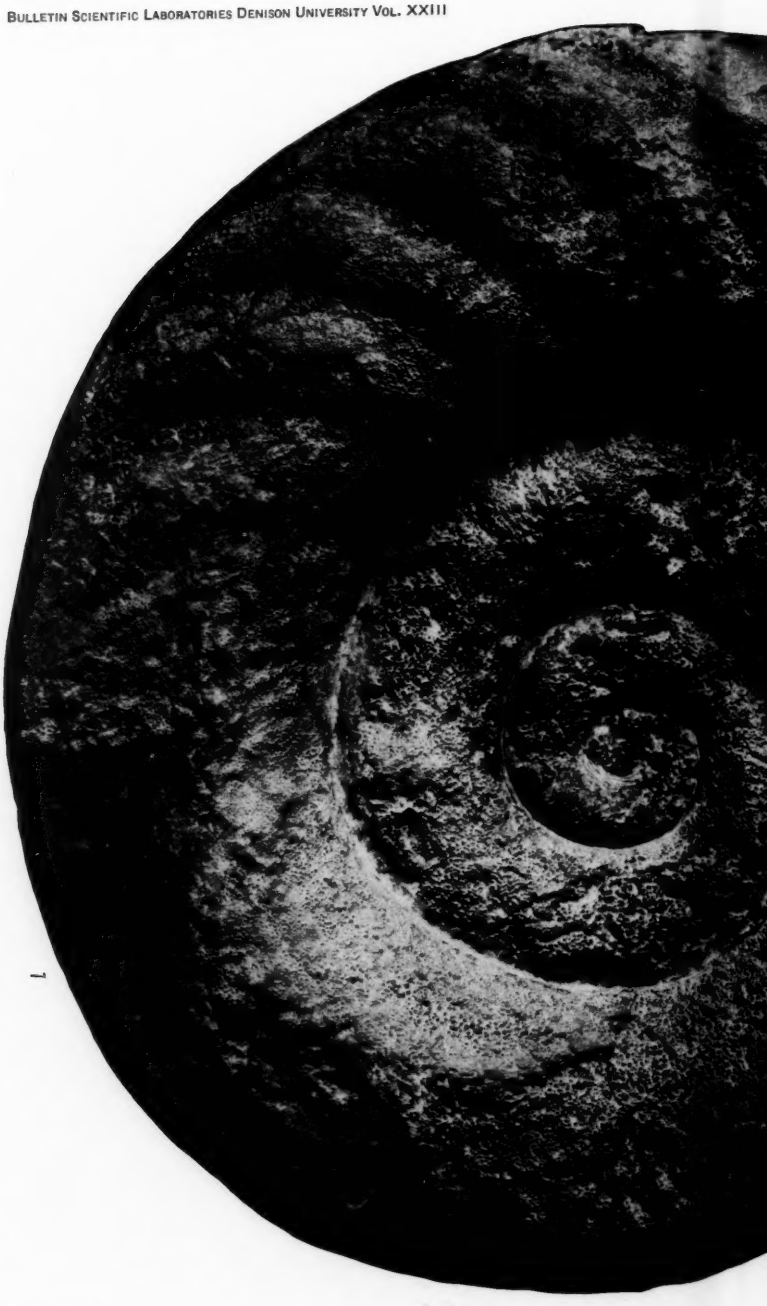


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PLATE XIX

Fig. 1. *Plectoceras lowi* Foerste. Weathered side of same specimen as that figured on pl. 18; with traces of siphuncle at four places, also showing the considerable thickness of the shell of the conch. Port Burwell, west of Cape Chidley in northern Labrador; in erratic blocks of Black River limestone. Specimen No. 7929 in the Victoria Memorial Museum. See also pl. 26, fig. 2.

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PLATE XIX

AMERICAN ARCTIC AND RELATED CEPHALOPODS

PLATE XX

Fig. 1. *Eurystomites chidleyense* Foerste. Lateral view, with the fractures across the conch numbered. Parts of this specimen are represented on pl. 2 by figs. 2 A–C. Port Burwell, west of Cape Chidley; at northern end of Labrador; in erratic blocks of Black River limestone. Specimen No. 7932 in the Victoria Memorial Museum. See also pl. 27, figs. 2 A–F.

X 0.9

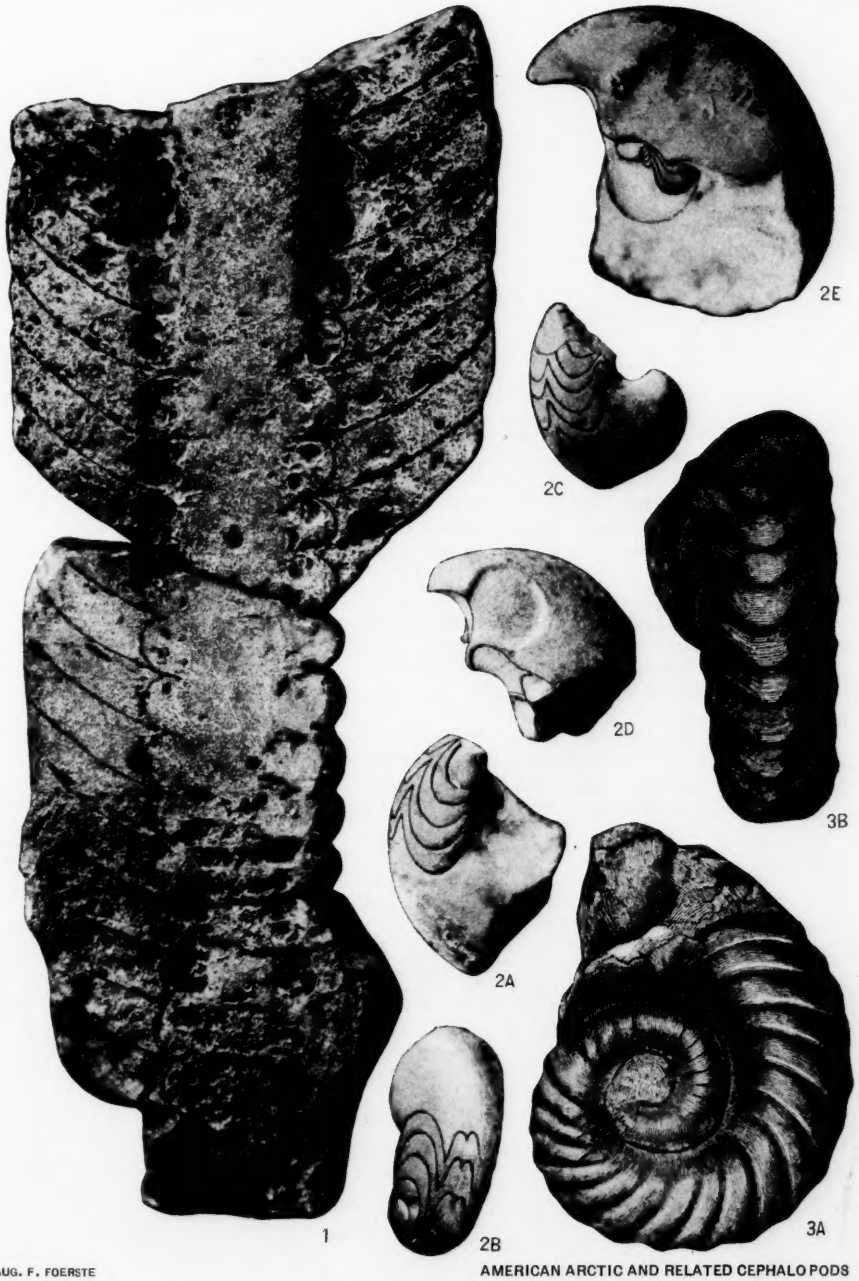
1

PLATE XXI

Fig. 1. *Armenoceras richardsoni* (Stokes). Natural weathered section of the interior of the type, partially smoothed so as to show the structure of the siphuncle and of the septa. Lake Winnipeg, Manitoba; probably from the Richmond. Specimen No. 33422 in the British Museum of Natural History. Type, of which Stokes figured only the lower half.

Fig. 2. *Manticoceras* cf. *pattersoni* (Hall). A, lateral view; B, same specimen, sufficiently oblique to show the course of the sutures of the septa along the ventral side of the conch and also along the adjacent parts of its lateral side, but oriented in a direction opposite to that used for fig. A. C, lateral view of another specimen oriented in the same direction as fig. A. D, lateral view of a living chamber, oriented in a direction opposite to figs. A and C, with septum exposed along upper part of left margin. E, lateral view of another specimen, oriented as in fig. D; consisting chiefly of the living chamber, but showing traces also of the adjacent inner volution. Abitibi River; Upper Devonian, approximately of Portage age. Collected by Professors T. E. Savage and Francis M. Van Tuyl, and now in the collection of Prof. Savage at the Univ. of Illinois. See also pl. XXVIII, figs. 3 A, B, C.

Fig. 3. *Plectoceras halli* (Foord). A, lateral view; B, ventral view, which fails to show the flattening of this ventral side of the conch, though described in the text of the original description. Lorette, 7 miles west of Quebec, in Canada; in the Black River formation. Type. Figures copied from Catalogue of Fossil Cephalopoda in the British Museum, pt. 2, 42, text figs. 4a, 4b (1891). Specimen stated by Foord to belong to the British Museum of Natural History. See also pl. 26, figs. 5, 6, taken from other specimens.



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AMERICAN ARCTIC AND RELATED CEPHALOPODS

PLATE XXII

Fig. 1. *Endoceras chidleyense* Foerste. A, cross-section showing size and location of siphuncle; B, diagrammatic vertical section in a dorso-ventral direction through the siphuncle, with ventral outline on left. See also pl. 2, fig. 1.

Fig. 2. *Cyclendoceras boreale* Foerste. A, cross-section showing size and location of siphuncle; B, diagrammatic vertical section in a dorso-ventral direction through the siphuncle, with ventral outline on right. See also pl. 1, figs. 1 A, B.

Fig. 3. *Sactoceras* (?) sp. (Griffith Island). A, cross-section, location of siphuncle unknown; B, vertical section through basal part of living chamber and the one camera still attached. See also pl. 11, fig. 4.

Fig. 4. *Cyclendoceras sp.* (Mount Beaufort). Cross-section, with indication of the apparent size and location of the vaguely indicated siphuncle. See also pl. 11, fig. 1.

Fig. 5. *Orthoceras* cf. *griffithi* Haughton. A, cross-section, showing size and location of siphuncle; B, vertical section through lower part of living chamber and the camera beneath. The form of the segments of the siphuncle is unknown. See also Jour. Sci. Labs. Denison Univ., 22, pl. 10, fig. 2 (1927).

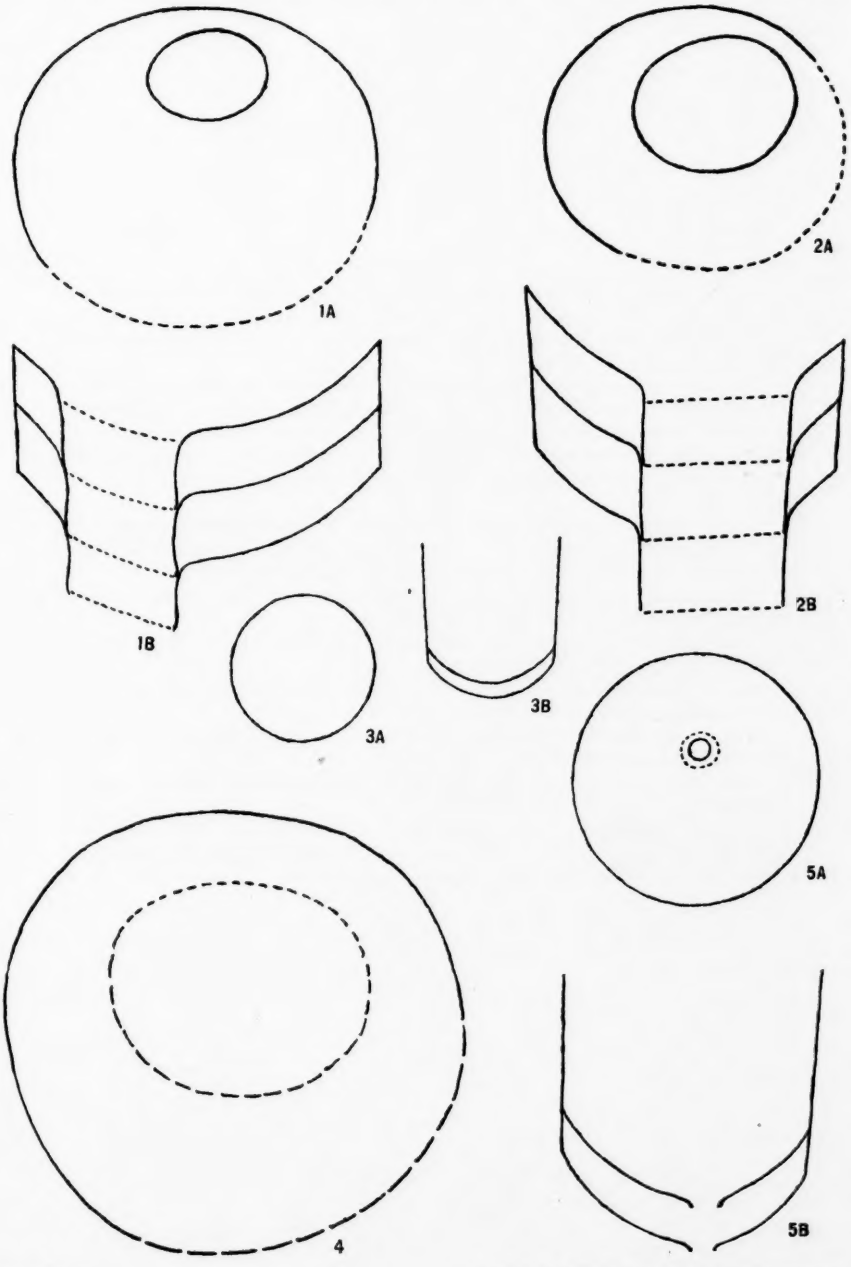

1A
2A
1B
2B
3A
3B
5A
4
5B

PLATE XXIII

Fig. 1. *Armenoceras naresi* Foerste. A, B, C, three cross-sections of the conch, showing size and location of siphuncle at top, middle, and base of specimen. D, vertical dorso-ventral section through the siphuncle, the latter narrowing toward the top. See also pl. 13, fig. 1.

Fig. 2. *Armenoceras sp.* (Dobbin Bay). A, cross-section attempting to give some idea of the relative size and location of the siphuncle; B, a similar attempt at a vertical dorso-ventral section through the siphuncle, of which only the ventral side is known; C, ventro-lateral vertical section extending from the ventral wall of the conch toward the center of the siphuncle, as actually exposed. See also pl. 12, fig. 3.

Fig. 3. *Beloitoceras* (?) *baffinense* (Schuchert). A, normal form of segment of the siphuncle in lateral section; B, form resulting at top of phragmacone where siphuncle is widened. Both figures magnified. See also pl. 8, fig. 1.

Fig. 4. *Spyroceras porteri* (Schuchert). Dorso-ventral vertical section through the siphuncle. See also pl. 7, fig. 2.

Fig. 5. *Beloitoceras arcticum* (Schuchert). Dorso-ventral vertical section through the siphuncle. See also pl. 8, fig. 6.

Fig. 6. *Ephippiorthoceras compressum* Foerste. Dorso-ventral vertical section through segment at base of specimen. See also pl. 7, fig. 9.

Fig. 7. *Beloitoceras* (?) *cornulum* (Schuchert). Dorso-ventral vertical section through siphuncle. See also pl. 8, fig. 8.

Fig. 8. *Thuleoceras ornatum* Troedsson. Dorso-ventral vertical section through siphuncle. See also pl. 8, figs. 2–5.

Fig. 9. *Troedssonoceras turbidum* (Hall and Whitfield). Vertical section through the siphuncle. From exposure on north side of Big Bend on Cumberland River, 2 miles above Wolf creek, in southern Kentucky. See also pl. 6, fig. 2.

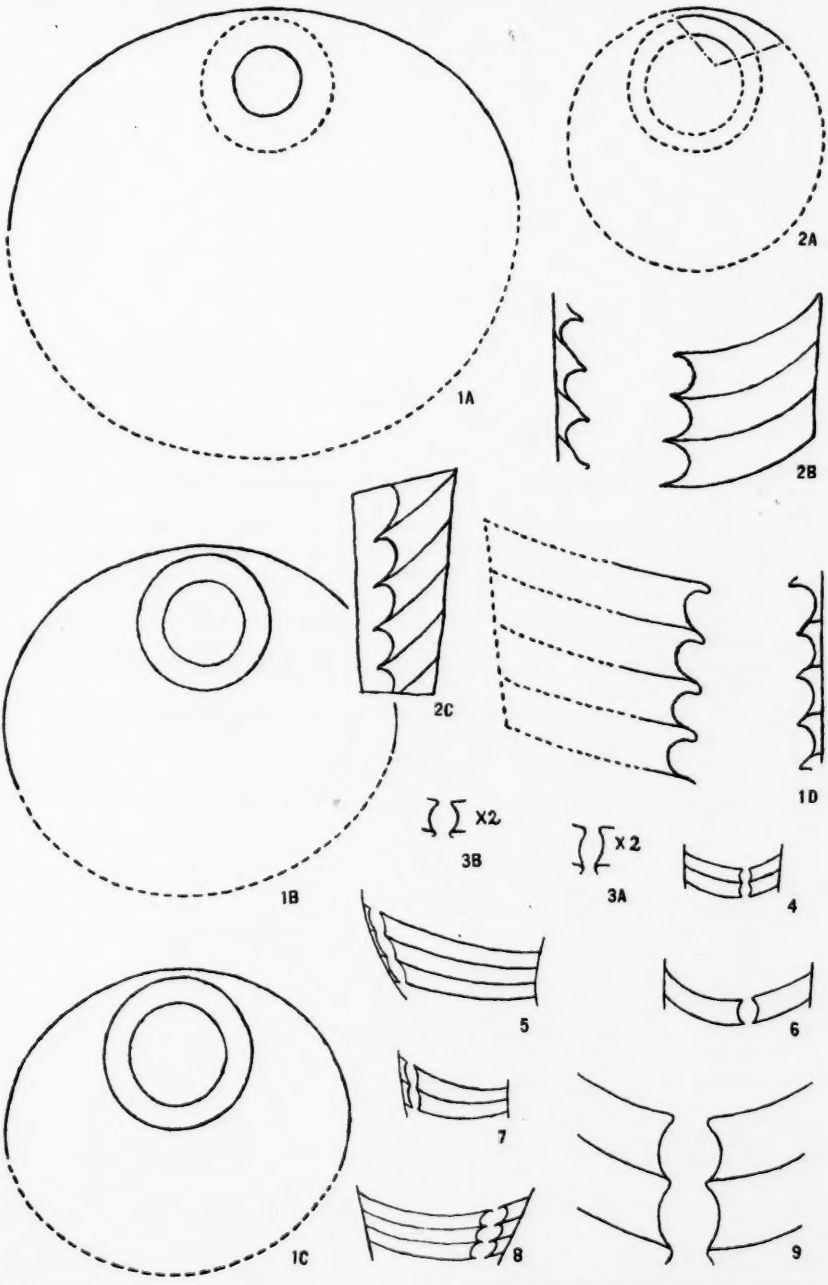

1A
2A
2B
2C
1D
1B
X2
3B
X2
3A
4
5
6
7
1C
8
9

PLATE XXIV

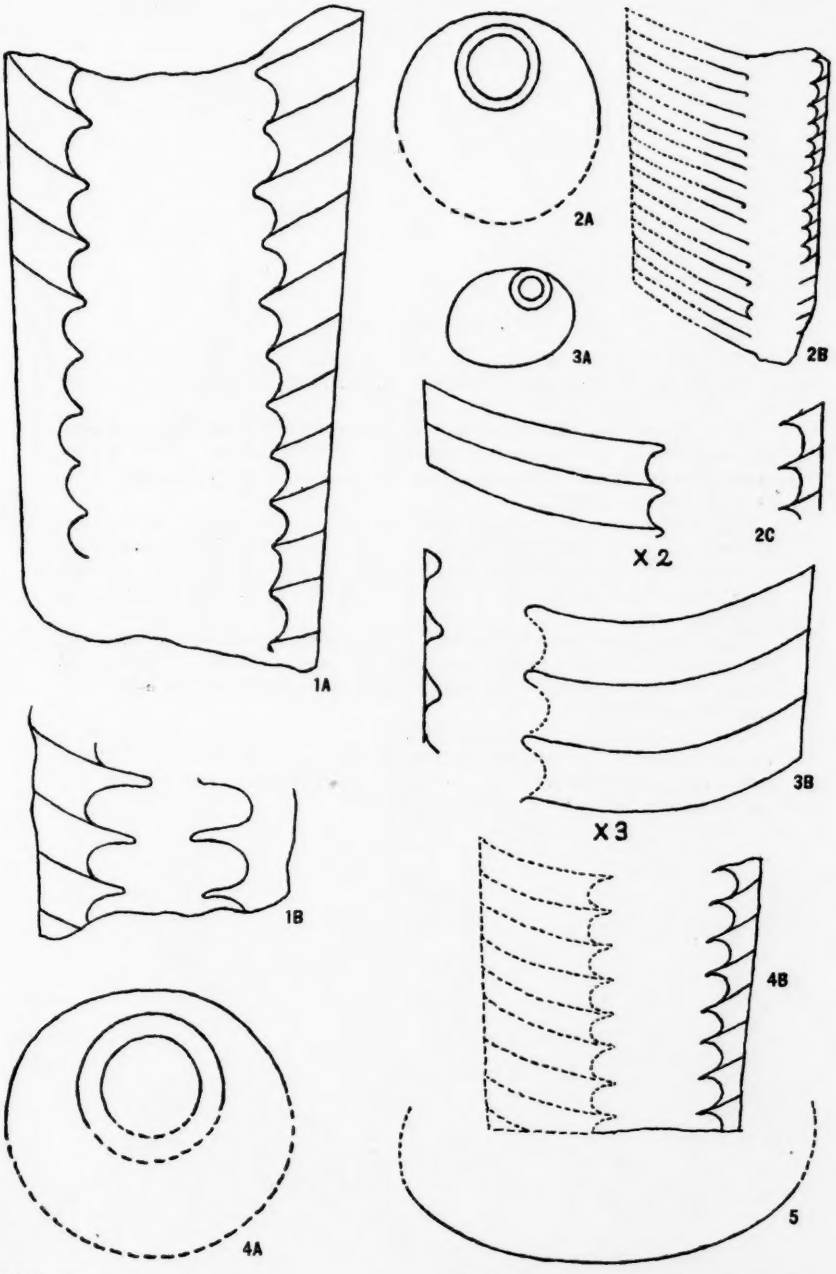
Fig. 1. *Armenoceras lyoni* (Stokes). A, section in lateral direction through center of siphuncle; B, section in lateral direction near ventral margin of siphuncle. Both sections prepared by Dr. F. A. Bather from type specimen. See also pl. 13, fig. 2, and pl. 14, fig. 1.

Fig. 2. *Armenoceras* cf. *ommaneyi* (Salter). A, cross-section, indicating size and location of siphuncle; B, vertical dorso-ventral section through siphuncle; C, vertical dorso-ventral section of same specimen enlarged 2 diameters. See also pl. 13, fig. 5 A, B.

Fig. 3. *Armenoceras donetti* Foerste. A, cross-section, indicating size and location of siphuncle; B, dorso-ventral vertical section through the siphuncle, magnified 3 diameters. See also Jour. Sci. Labs. Denison Univ., 22, pl. 3, fig. 6 (1927).

Fig. 4. *Armenoceras coppingeri* Foerste. A, cross-section indicating size and location of siphuncle; B, dorso-ventral vertical section through the siphuncle with its dorsal half restored. See also pl. 12, fig. 1.

Fig. 5. *Armenoceras sp.* (Offley Island). Cross-section of the small part preserved, lateral outline unknown. See also pl. 12, fig. 2.



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AMERICAN ARCTIC AND RELATED CEPHALOPODS

PLATE XXV

Fig. 1. *Kochoceras lenticulare* Foerste. A, an attempt at a cross-section; B, diagrammatic lateral view of specimen. See also pl. 11, fig. 3, and Jour. Sci. Labs. Denison Univ., 22, pl. 7, fig. 1, (1927).

Fig. 2. *Kochoceras feildeni* Foerste. A, an attempt at a cross-section showing size and location of siphuncle; B, diagrammatic vertical dorso-ventral section through the siphuncle. See also pl. 11, fig. 2, and Jour. Sci. Labs. Denison Univ., 22, pl. 10, figs. 1 A–C (1927).

Fig. 3. *Ormoceras sp.* (Arctic America). A, vertical section through the siphuncle; B, same, with probable location and form of the septa and the walls of the siphuncle; C, hypothetical form of septa and walls of siphuncle, separate from filling of interior of same. See also Jour. Sci. Labs. Denison Univ., 22, pl. 2, fig. 3 (1927).

Fig. 4. *Kochoceras mantelli* Foerste. A, vertical dorso-ventral section through the siphuncle; B, lateral view of specimen, with ventral outline on right, dorsal margin of segments weathered back. See also Jour. Sci. Labs. Denison Univ., 22, pl. 7, fig. 3 (1927).

Fig. 5. *Armenoceras* cf. *rotulatum* (Billings). A, vertical dorso-ventral section through siphuncle, with ventral outline on left; B, cross-section of siphuncle indicating also the size of its constriction at the septal neck. See also Jour. Sci. Labs. Denison Univ., 22, pl. 16, fig. 4 A, B (1927).

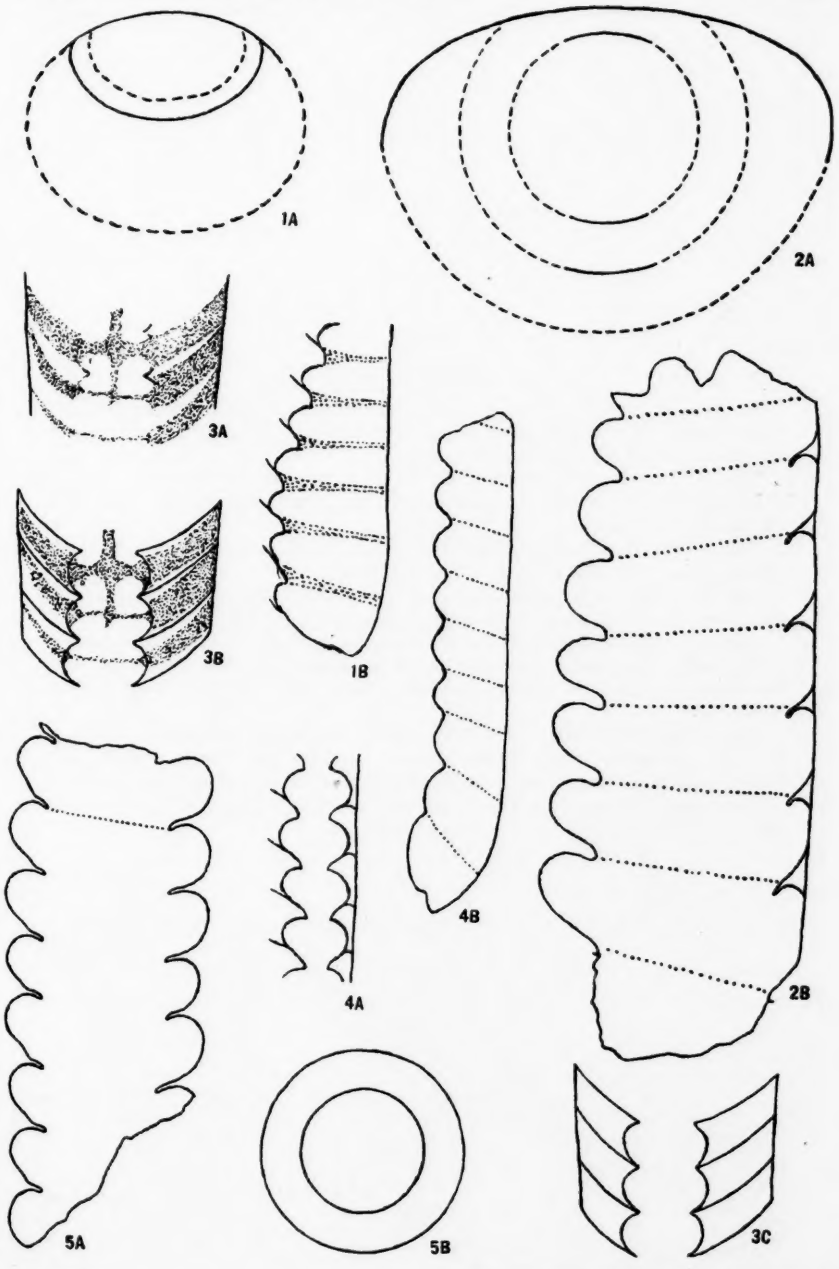
1A
2A
3A
3B
1B
4B
2B
4A
5A
5B
3C

PLATE XXVI

Fig. 1. *Plectoceras occidentale* (Hall). Cross-section passing through the larger end of the living chamber and the two adjacent volutions of the phragmacone. See also pl. 3, fig. 2, and pl. 17, fig. 1.

Fig. 2. *Plectoceras lowi* Foerste. Cross-section through the larger end of the living chamber, and the three adjacent volutions. See also pl. 18, fig. 1, and pl. 19, fig. 1.

Fig. 3. *Plectoceras undatum* (Conrad). Cross-section of two volutions of the phragmacone. See also pl. 15, fig. 2, and pl. 16, fig. 1.

Fig. 4. *Plectoceras undatum* (Conrad). Cross-section through larger end of conch and the two adjacent volutions. See also pl. 15, fig. 1 A, B.

Fig. 5. *Plectoceras halli* (Foord). Cross-section of conch showing flattening of ventral side, also location of siphuncle. Same specimen as Pal. New York, 1, pl. 13, figs. 1a, 1b (1847), from Watertown, New York; in the Black River limestone.

Fig. 6. *Plectoceras halli* (Foord). Cross-section through three adjacent volutions of a specimen in the Greene Museum at Milwaukee-Downer college, in Milwaukee, Wisconsin, showing the characteristic flattening of the ventral side of the conch. Judging from the matrix, this specimen also was obtained from the Black River limestone at Watertown, New York.

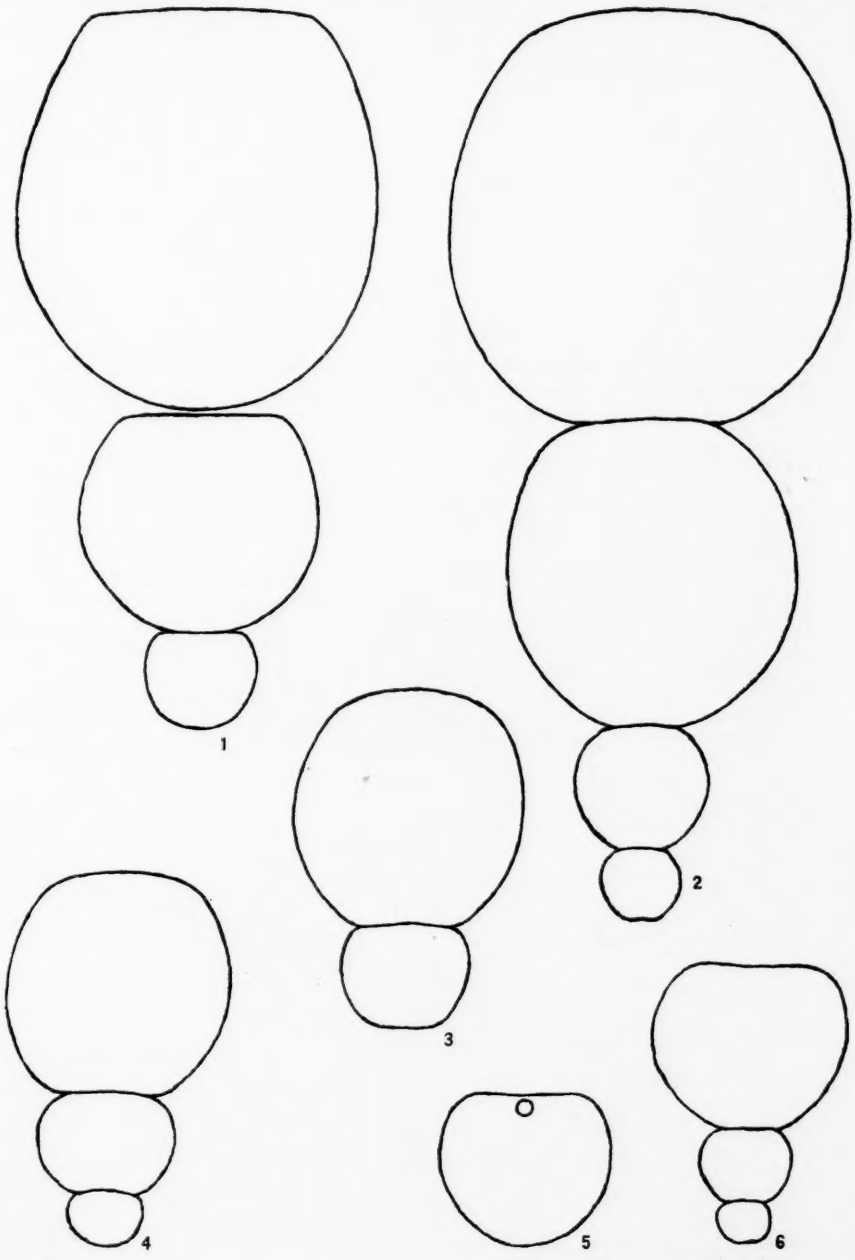

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PLATE XXVII

Fig. 1. *Eurystomites kelloggi* (Whitfield). A, cross-section of larger end of living chamber, showing dorsal impressed zone. B, ventral side of larger end of phragmacone, showing faint ventral lobes in sutures of the septa. See also pl. 16, fig. 2.

Fig. 2. *Eurystomites chidleyense* Foerste. Cross-sections and one dorso-ventral section located at or between fractures as indicated on pl. 20, fig. 1. A, at fracture 9; B, at fracture 8; C, near fracture 8; D, at fracture 5; E, at fracture 3, including also the adjacent smaller volution; F, at fracture 2. See also pl. 2, fig. a A–C.

Fig. 3. *Eurystomites kelloggi* (Whitfield). Dorso-ventral section through the siphuncle of specimen No. 25649 in the U. S. National Museum, from Fort Cassin, Vermont, from the Upper Canadian part of the Beekmantown.

Fig. 4. *Charactoceras schucherti* Foerste. A, two cross-sections of the phragmacone, the smaller one locating the siphuncle; B, dorso-ventral section passing through the siphuncle; C, dorso-ventral section magnified, showing the septal necks of three septa where the connecting rings are absent; D, similar enlarged section, showing also the connecting rings. See also pl. 9, fig. 2 A–C.

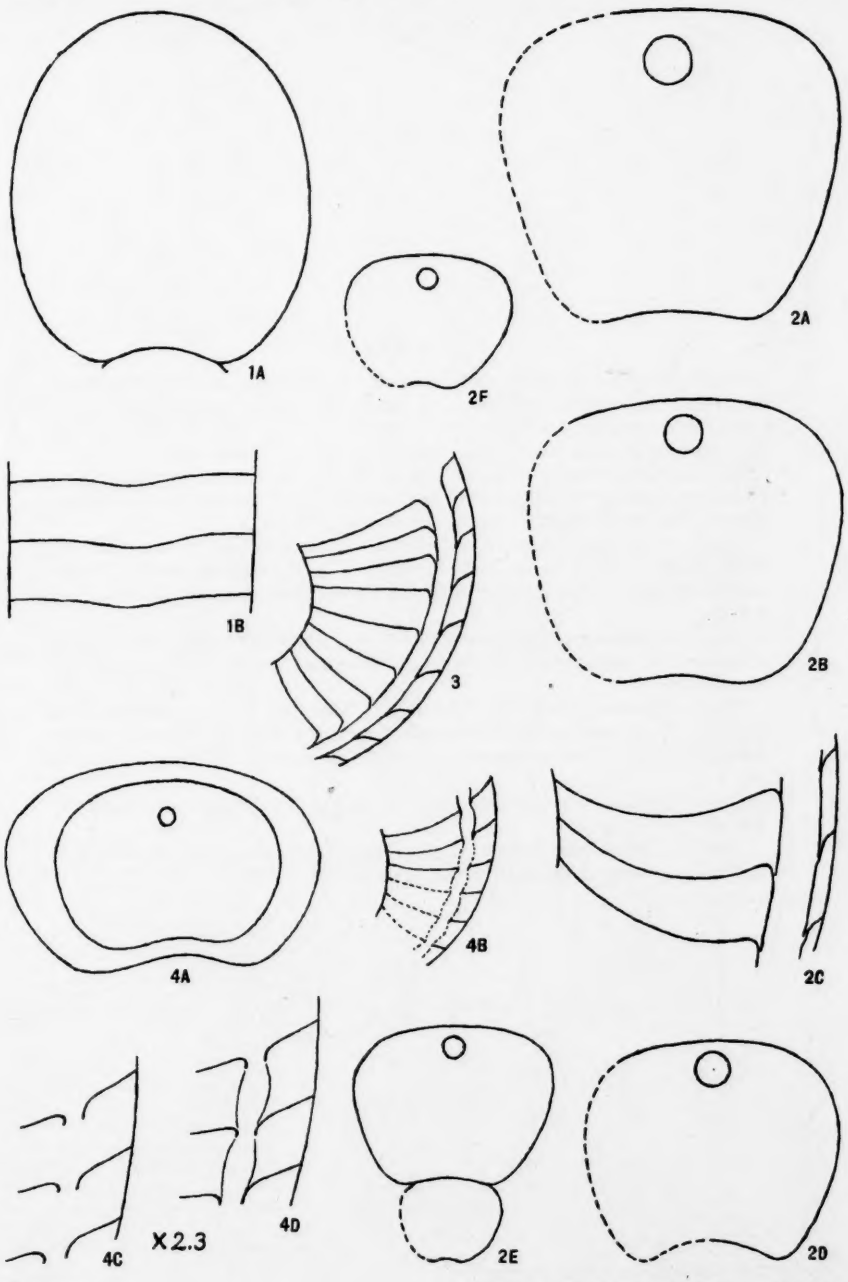
1A
2F
2A
1B
3
2B
4A
4B
2C
4C
X 2.3
4D
2E
2D

PLATE XXVIII

Fig. 1. *Armenoceras sphaeroidale* (Stokes). A, cross-section of the triangular fragment at hand, with an attempt to restore the original cross-section of the conch; B, an imaginary vertical dorso-ventral section through the siphuncle and the ventral side of the conch. See also pl. III, fig. 5. Dobbin Bay.

Fig. 2. *Actinoceras sp.* Ventral side of the specimen, with segments of siphuncle apparently in contact with the ventral wall of the conch, or nearly in contact. Bering Straight, Alaska. See also pl. VII, fig. 3.

Fig. 3. *Manticoceras* cf. *pattersoni* (Hall). A, suture at base of living chamber represented by fig. 2E on pl. XXI; B, suture of fig. 2A on plate cited; C, cross-section at base of living chamber of fig. 2D of same plate. See also pl. XXI, figs. 2 A–E.

Fig. 4. *Dawsonoceras americanum* (Foord). A, transverse striae, magnified two diameters; B, vertical outline, showing number and degree of elevation of the annulations.

Fig. 5. *Dawsonoceras granti* Foerste. A, transverse striae, magnified 2 diameters; B, vertical outline of left side of specimen showing relatively narrow annulations and broad intervening grooves. See also pl. IV, fig. 1, and pl. V, fig. 5.

Fig. 6. *Dawsonoceras hyatti* Foerste. Transverse striae, magnified 2 diameters. See also pl. IV, fig. 2.

Fig. 7. *Dawsonoceras annulatum* (Sowerby). Vertical outline, showing number and elevation of the annulations. See also pl. V, fig. 1.

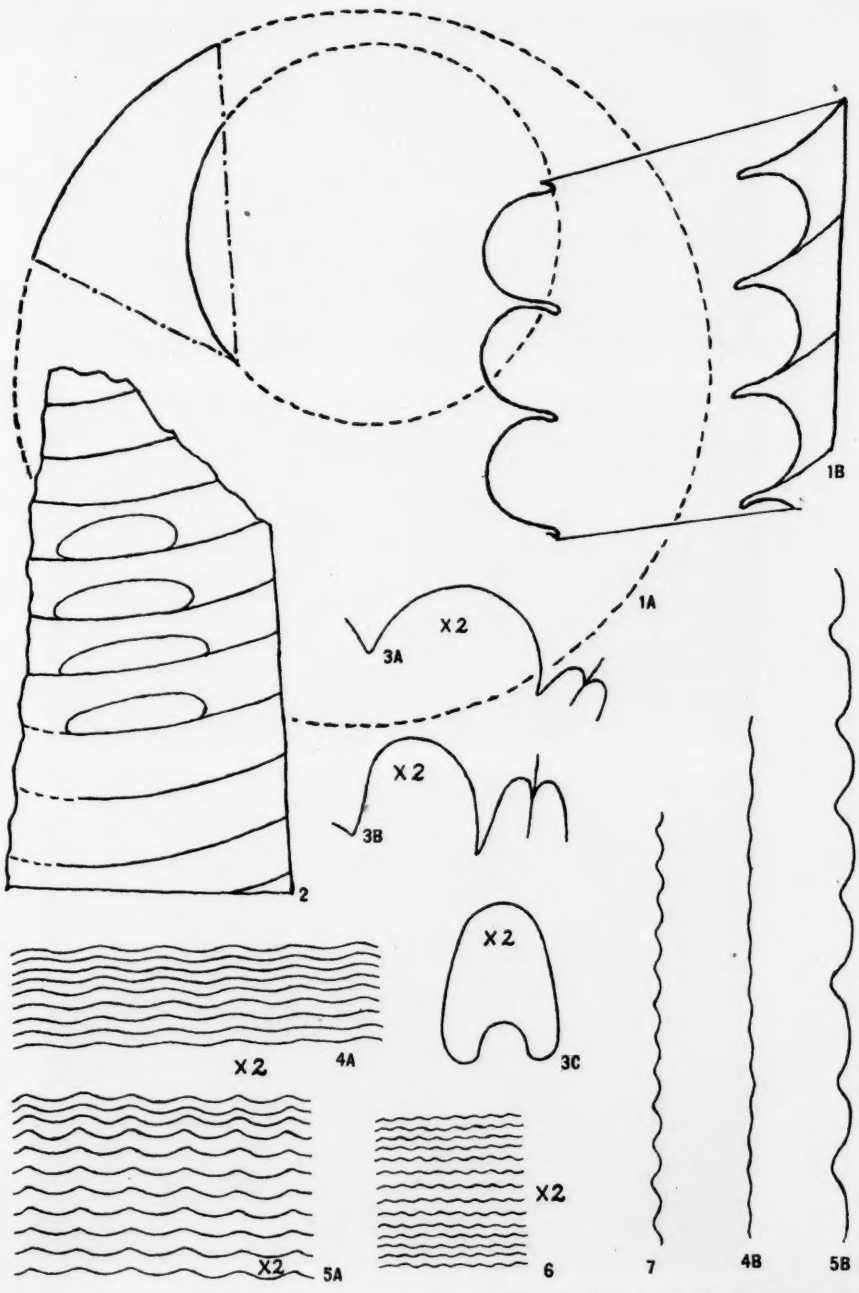
1B
1A
X2
3A
X2
3B
2
X2
3C
X2
4A
X2
5A
X2
6
7
4B
5B

PLATE XXIX

Fig. 1. *Metaconularia papillata* (Hall). Part of surface, magnified 12 diameters. Trenton Falls, New York; in the Trenton. No. 27810, in Museum of Comparative Zoology, at Harvard University.

Fig. 2. *Metaconularia granulata* (?) Hall. Part of surface, magnified 12 diameters. Trenton Falls, New York; in the Trenton. No. 27809, in Museum of Comparative Zoology, at Harvard University.

Fig. 3. *Metaconularia ulrichi* Foerste. Part of surface, magnified 12 diameters. From Platteville, Wisconsin, in Platteville. In U. S. National Museum.

1

2

3

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APATODONOSAURUS, A NEW GENUS OF ICHTHYOSAURS FROM THE JURASSIC OF WYOMING

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During the summer of 1926, students from the University of Missouri engaged in special investigations of Mesozoic formations in Wyoming made several important discoveries of vertebrate remains. One of the most interesting of these was that of an ichthyosaur in the Sundance formation.

A considerable number of ichthyosaur specimens has been found in the Jurassic of South Dakota and Wyoming. Apparently the majority of such finds have come from southeastern Wyoming, but unfortunately many of the locations are mentioned in the literature in a casual manner only and there seem to be no complete published data on their geographic distribution. So far as the writer can learn the present specimen, from Fremont County, is a record for the western extension of ichthyosaurs in Wyoming.

NATURE OF THE MATERIAL

The bone is very well preserved for the most part, in an extremely hard, calcareous, nodular matrix. It is likely that more careful examination of the talus from which most of the specimen came will supply missing parts, for the material collected shows many fresh breaks without duplicate sections.

The remains consist of parts of the skull and jaws; part of one of the limbs; and numerous vertebrae and ribs representing the various regions of the column.

The present data seem to exclude the specimen from known genera, and warrant perhaps a descriptive record, fragmentary as it necessarily must be.

THE SKULL

A comparatively small part of the skull is available for study; chiefly part of the left side in the region below and in front of the orbit. In detail, the material consists of a small section of the slender part of the rostrum, a considerable portion about the left narial opening with a posterior extension along the lower border of the skull to near the quadrate, a separate quadrate bone, about one-half the left schlerotic ring or capsule along with the internal mold of the right, and several fragments of doubtful position.

While its fragmental nature leave many of the important features of the skull in doubt or entirely unknown, certain characteristics are evident and furnish the basis for a logical interpretation of others. Much of the accompanying outline restoration (Plate XXX) is largely hypothetical, but the comparatively slight depth of the ramus in the narial region is fairly well established and the isolated section from considerably farther forward bespeaks a long, slender snout. Or again, although no part of the orbit margin is preserved, the position of the opening can be varied only within narrow limits. Its position emphasizes the markedly anterior nares and, at the same time, a wide post-orbital bar.

Another striking feature is the small size of the orbit. As determined from the schlerotic capsule this opening is essentially circular and relatively much smaller than in any previously known ichthyosaur genus.

Other features, apparently unique among ichthyosaurs, but less well established, perhaps, are indicated in the arrangement of the bones in the orbito-narial region, as will be discussed presently.

SEPARATE BONES OF THE SKULL

The union of the several elements of the skull is in the nature of simple overlaps rather than intricate suture. For this reason fractures may well complicate the interpretation. For the most part, however, the determination of sutures may be verified by

cross-sections. If the writer's interpretation is correct, the development of the several bones, particularly those about the nares, is markedly different from the condition common among ichthyosaurs, as is indicated in Plate XXX.

The *premaxilla* is exceptionally large. The two together make up almost the entire rostrum. At its posterior end the premaxilla connects with the jugal, lachrymal, and prefrontal, as well as with the nasal and the maxilla, by means of a long slender process that extends nearly to the orbit. This element forms most of the posterior border of the nares and excludes the maxilla from that opening.

The *maxilla* is a narrow, comparatively short bone, quite different from the common triangular development of the ichthyosaurs. Its length along the lower margin of the skull, essentially its greatest length, is apparently about 260 mm. it seems impossible that it should have extended posteriorly as far as the orbit.

The extent of the *nasal* can not be determined. It is evident, however, that its posterior articulation is with the frontals and prefrontals only. The nasal overlaps the prefrontal with a series of long, slender, digitate processes. These processes originate through a furrowing of the lower posterior margin of the nasal by deep grooves that extend posteriorly from a row of conspicuous foramina along a line that divides the bone into a lower and an upper half. The nasals form the entire upper margin of the nares.

The *frontals* apparently are not represented.

The *prefrontal* is an essentially triangular bone extending along the lower, posterior margin of the nasal to the nares where it forms a small part of the posterior border of that opening. Along its lower margin it articulates broadly with the premaxilla as indicated above.

The *lachrymal* seems to overlap the lower posterior corner of the prefrontal and to articulate along its lower margin with the premaxilla to a slight extent and somewhat more broadly with the jugal. It does not, however, articulate with the maxilla.

The *jugal* is considerably broader than in other ichthyosaur genera and is further unique in extending forward on the outer surface of the skull considerably beyond the anterior margin

of the orbit. It actually extends forward to the nares, but the overlapping maxilla conceals much of the anterior end. The posterior end of the suborbital bar is broken, but there appears to be a firm sutural union of the jugal with the quadrato-jugal as indicated.

The *quadrato-jugal* is represented only in part; a small triangular section from the lower anterior end closely united suturally with the jugal. Its length along the lower border of the skull must have been as much as 175 mm. This part of the skull margin projects downward in a broadly rounded lip so as to overlap the coronoid region of the lower jaw.

Part of a *quadrate* bone, presumably, from the right side, is preserved, but does not permit adequate description of that element. There is every evidence, however, that the post-orbital bar is exceptionally wide.

THE SCHLEROTIC RING

No part of the border of the orbit is preserved, consequently only the approximate position of this opening can be indicated. Part of the internal mold of each of the schlerotic rings is preserved. Although most of the bone has been lost the impressions of the plates are clear on one of the molds and enough of the bony plates adhere to give an accurate idea of all essentials. The ring was formed by about fourteen plates closely united into an inflexible capsule. While the impressions on the matrix and the bone surfaces themselves show a straight line union between the plates suggestive of simple overlapping, sections across adjacent plates show clearly a complicated interlocking as indicated in the accompanying diagram, figure 1a. The pupillary opening is approximately 70 mm. in diameter. From the plane of the pupillary opening the schlerotic plates slope away at an angle of slightly more than 45°. At a distance of about 50 mm. from the margins of the opening, measured along the plates, the greatest diameter of the capsule is reached, about 140 mm. At this line the plates bend abruptly back, almost at right angles as indicated in the accompanying diagram. Assuming that the schlerotic ring or capsule, as it is more appropriately designated,

essentially filled the opening, the orbit was remarkably small for an ichthyosaur.

THE LOWER JAW

The left ramus of the lower jaw, from near the posterior extremity to somewhat beyond the symphysis is represented by several large sections. While there are gaps between the sections there can be no doubt of their relative positions. Two large, well preserved pieces from the post-symphysial region of the right ramus supplement and check the data as determined from the left side. A single section from about mid-length of the symphysis gives a fair idea of that part of the jaw.

FIG. 1. APATODONOSAURUS GRAYI; CROSS-SECTION OF SCHLEROTIC CAPSULE WITH DETAIL (*a*) OF INTERLOCKING PLATES

One-half natural size

There has been an infiltration of white calcite between the various elements that make up the mandible such that the relationships, especially as seen in cross-sections, is very clearly shown with few exceptions. A total length of about 54 inches is indicated. The post-symphysial length is approximately 30 inches. The accompanying cross-sections, figure 2, show the development of the several bones more clearly than could be done by written descriptions. There are, however, certain doubtful relationships that require some discussion.

In an attempt to homologize certain of the posterior elements, particularly the coronoid, with the development in *Baptanodon* as described by Gilmore[1] and the Triassic genera figured by

[1] C. W. Gilmore; Osteology of Baptanodon (Marsh). Memoirs of the Carnegie Museum, 2, No. 2, 77–129 (1905).

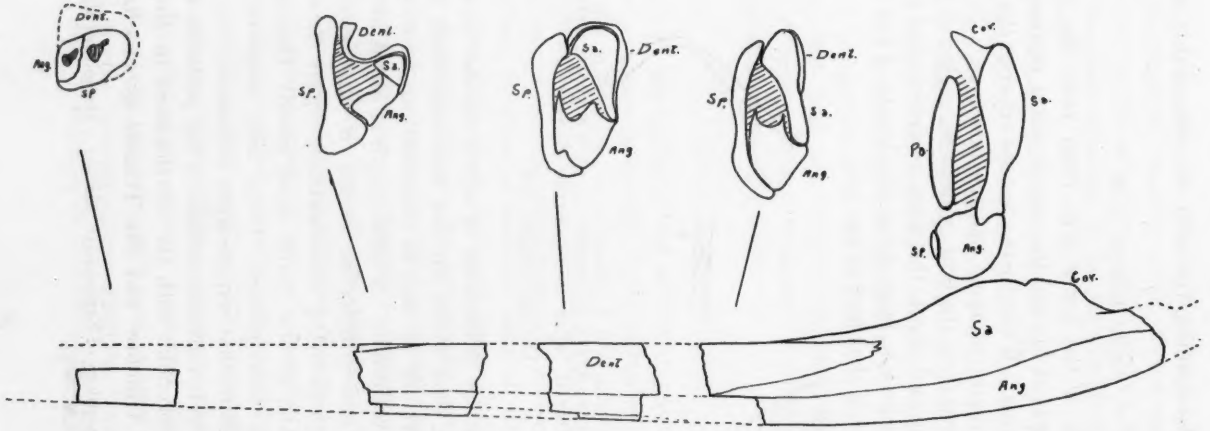


FIG. 2. APATODONOSAURUS GRAYI; LEFT RAMUS OF LOWER JAW WITH CROSS-SECTIONS (VIEWED ANTERIORLY)

Sp., splenial; *Ang.*, angular; *Sa.*, surangular; *Pa.*, prearticular; *Cor.*, coronoid process; *Dent.*, dentary. About one-third natural size.

Merriam,[2] the writer has found certain difficulties. It seems likely that the previous determinations of the bones at the posterior end of the ramus have been somewhat in error or the present specimen has a very exceptional development of this part of the mandible. The evidence indicates the former. As pointed out by Merriam[3] in connection with *Cymbospondylus*, a distinct coronoid elevation is generally lacking in ichthyosaur genera.

As indicated in the accompanying drawing, figure 2, there is a pronounced *coronoid elevation* in the form here described. The process is remarkably well developed on both rami and is taken to be the coronoid. On the left ramus it seems to be a part of or a complete fusion with the surangular. On the right side it is clearly separated from the surangular, but this may be the result of a calcite filled fracture rather than a sutural union. In the temnospondyl amphibians and primitive reptiles the coronoid was a development about the anterior and the anterior-lateral border of the dentary with a slender process extending forward along the inner side of the Meckelian orifice. Never, so far as the writer is aware, did it form a conspicuous part of the inner margin of that opening nor did it take part in the margin of the inferio-posterior Meckelian foramen. In later reptiles the coronoid has been restricted to the posterior end of the dentary about the antero-lateral margin of the Meckelian orifice or has been completely lost. The writer assumes that in most of the ichthyosaurs it has been very much reduced and completely fused with the surangular or completely lost. The present form would represent a transitional stage.

With such an interpretation the rather doubtful development of the inner posterior surface of the ramus is apparently clarified, at least for the North American Jurassic forms.

The *articular* is missing in both of the rami. There can be no doubt of its relations, however, if the above interpretation of the coronoid is correct. It was clasped by the angular, surangular,

[2] John C. Merriam; Triassic Ichthyosauria with Special Reference to the American Forms; Memoirs of the University of California; 1, No. 1, 1–196 (1908).

[3] Ibid., p. 26.

and the prearticular. Neither the coronoid nor the splenial could have taken part in the union as has been the interpretation in *Baptanodon*. This again, is the normal development in the early and even the later reptiles.

The *angular* forms the lower border of the posterior half of the post-symphysial region. From here forward it is visible on the outer side as a narrow band extending somewhat beyond the symphysis between the dentary and the splenial.

The *surangular* forms a conspicuous part of the outer-posterior side of the jaw. Although it is concealed in front of the posterior fourth of the jaw by the overlapping dentary, it continues forward somewhat beyond the union of the rami.

The *prearticular* is a broad, plate-like bone conspicuous on the inner posterior side of the jaw. In the present specimen its relation with the splenial is evident. The prearticular does not extend far beyond the point where it is overlapped by the splenial.

The *splenial* has much the same development as in *Baptanodon*. It is apparently visible on the lower side of the ramus somewhat further forward in the present form, however, and clearly is of more importance in the symphysial region.

The *dentary*, in its post-symphysial extent, is merely a thin veneer as indicated in the accompanying cross-sections. It is only in the long symphysis that this element could have played an imporant part.

Gilmore notes an internal mandibular foramen just back of the symphysis in *Baptanodon* which "appears to be wholly inclosed by the splenial."[4] In the present specimen the internal mandibular foramen is far back toward the posterior end of the ramus. Above and below, the margins are formed by the prearticular and the angular respectively. The splenial forms the anterior border. It seems likely that in *Baptanodon* the opening represents the anterior of the two internal openings as displayed in the temnospondyl amphibians and some of the early reptiles. In *Trimerorhachis*, for instance, the anterior foramen is between the splenial and post-splenial while the posterior foramen has the relations as shown on the present form.

[4] Op. cit., p. 96.

THE DENTITION

While many of the details on the dentition are not evident, some of the broader and perhaps more important features are determinable. The teeth are of two rather distinct varieties, each apparently confined to a particular part of the jaw margin. One set of examples comes from a section of the long slender rostrum, apparently about mid-length. These teeth are without doubt from the premaxillary. Of the other type there are two collections, both in the matrix adhering to the lower jaw. One of the fragments comes from a little back of the symphysis. The other is a section from about mid-length of the post-symphysial region. Both of these collections are probably from the maxilla. It would seem, therefore, that while there is likely a gradation from the anterior to the posterior series, there is a typical premaxillary and a typical maxillary dentition.

The *premaxillary teeth* are slender, finely fluted cones—sharp and slightly recurved. Those available for measurement indicate an average length of 15 mm. and a diameter at the base of 6 mm. The nature of the base is not clear, but it seems to be similar to that of the maxillary series to be described later. The teeth are set in broad pits—shallow, but well marked. A thin film of matrix intrudes between the base of the tooth and the bone surface of the pit indicating clearly that the attachment was of a fleshy nature. The teeth were spaced about 14 mm. from center to center and directed markedly in toward the median line of the rostrum. The lateral alveolar margin was very deep, reaching down considerably further than the longest teeth (Plate XXXI, fig. 2). This coupled with the inwardly directed tips of the teeth make it evident that the longest in this part of the series could not have been functional, a fact that has suggested the name, *Apatodonosaurus*.

The *maxillary teeth* are for the most part in the normal position and are preserved as downward pointed tips only. A few of the teeth are apparently displaced and it is these that are available for description. The maxillary series are typically short, stout, finely fluted cones. The average length seems to be about 16

mm. and the diameter at the base is about 10 mm. The fluting extends from near the base to slightly below the tip. The lower margin of the cone is tucked under in radiating folds to form a base in the center of which a comparatively small opening, about 3.5 mm., leads into the large pulp cavity. Nothing can be said of the spacing of this series. Very likely this part of the dentition was of some use in holding fishes for it apparently extended somewhat into the alveolar groove of the lower jaw.

The lower jaw was probably edentulous. Certainly in the parts preserved there is nothing to suggest the presence of teeth. The dentary is a thin veneer only in its post-symphysial extent without suggestion of pits. Most important, however, is the fact that none of the teeth imbedded in the adhering matrix is directed away from the lower jaw.

THE VERTEBRAE

Several vertebrae representing parts of the cervical, dorsal and the anterior caudal series, fifteen in all, are available for study. Except for the absence of neural arches, all are fairly well preserved and undistorted. A definite position can not be assigned to individual vertebrae inasmuch as only four were found in a connected series.

The cervicals. Six of the collection of vertebrae are undoubtedly from the cervical region, apparently well forward. Four of them, Nos. 503.3, 503.4, 503.5, and 503.6, were found articulated. Two others, Nos. 503.1 and 503.2, seem to come from somewhat farther forward. They were probably separated from the connected series by two or three vertebrae which have been lost. All of this series are essentially the same, differing only in minor details that seem to represent a gradation from one end to the other.

The articular faces are essentially circular, about 83 mm. in diameter, except for the excavation for the neural canal. This circularity is modified by the parapophysial and diapophysial protuberances so as to give a shield shape outline to the vertebra as a whole. In length they increase from 33 to 43 mm. A de-

scription of the first of the series, No. 503.1, will serve for all (Plate XXXIII, fig. 1).

The centrum is deeply bi-concave, lacking but little of complete piercing. The anterior and posterior faces are slightly, not conspicuously flattened near the margins. The slope from near the margins to the point of the concavity, which is nearly central, is not in a straight line as seen in longitudinal sections through the center but somewhat convex—greater, apparently, below than above the center. Antero-posteriorly the lower and lateral sides of the centrum are but slightly concave. The floor of the neural canal is deeply excavated in the upper surface and is set off distinctly from the articular facets for the reception of the arch by thin, antero-posterior ridges. The neuropophysial articulations are in the form of conspicuous, deep pits. These are essentially circular in outline, about 20 mm. in diameter. These pits lie about mid-length of the centrum.

The diapophyses form marked, broadly-rounded protuberances on the upper anterior margin of the centrum. They form the rounded outer rim of the neuropophysial pits. The anterior margin of the processes round into the centrum face, but the posterior and lower posterior margins are set off by an abrupt rise from the body of the centrum.

The parapophyses are short but distinct processes rising from about half way down the centrum. They are near the anterior face of the centrum, but apparently do not merge with it. The articular face is nearly flat, oval in outline, 20 mm. high and 15 mm. wide. These faces are directed slightly forward and up. The diapophyses and parapophyses are separated by a space of at least 20 mm. and show no tendency to unite.

The dorsal series. At least six of the preserved vertebrae are from the dorsal series. No two of these are enough alike to have been closely associated. Apparently, each is representative of a section of the dorsum, the sections being regularly distributed from near the anterior to the posterior end.

Throughout the series the height and width of each vertebra are essentially the same. The dimensions increase regularly from the first to the last. The length is essentially constant—

about 45 mm. Through regular stages the outline of the faces changes from essentially circular at the anterior end of the series to somewhat pear-shaped at the posterior end.

The double articulations for the rib migrate regularly from relatively high on the centrum of the first to well down on the last of the series.

The most anterior of the preserved dorsals, No. 503.7 (Plate XXXII, fig. 2), has a diameter of 100 mm. and a length of 40 mm. It is deeply bi-concave. The points of the concavities are slightly below the center. The articular faces, particularly the anterior one, slope gently into the concavity for a short distance from near the margin. Toward the center the slope is abrupt.

The pits with which the neural arch articulates are considerably longer than wide and are directed antero-posteriorly. Each is sharply set off by thin antero-posterior ridges on either side.

The diapophyses and parapophyses are equally spaced above and below the mid-height line. Both processes are short but distinct. The diapophyses is somewhat the larger and longer. Its articular face is oval, about 18 mm. high and 11 mm. wide. It is directed laterally. The process is distinct from, but rises near the margin of the anterior face. The parapophyses rises from about mid-length of the centrum. Its articular face is about 15 mm. high and 11 mm. wide. It is directed laterally. The process is separated from the diapophysis by a distance of 20 mm.

The last representative of the dorsal series, No. 403.12 (Plate XXXIII, fig. 1), is markedly flattened on the lower side. It is 110 mm. high and somewhat less in width. The margins of the anterior face, particularly the lateral sides, are broadly rounded. The posterior face slopes from the margins to the center with little suggestion of marginal flattening. The neural canal excavation is notably narrower than at the front of the series, 19 mm. as compared with about 27 mm. The diapophyses and parapophyses are low on the centrum. The parapophyses and the lower surface of the centrum form nearly a straight line. The articular face of the diapophyses is circular, 12 mm. in diameter, somewhat larger than that of the parapophyses. Both

are directed laterally. While these two articulations are but a short distance apart, only 10 mm., there is little suggestion of their union, even at the base. The parapophysis rises from near mid-length of the vertebra. The diapophysis is somewhat farther forward.

The caudal series. Three of the collection of vertebrae, Nos. 503.13, 503.14, and 503.15, are taken to be from the caudal series close to the anterior end. All are of the same size, essentially as high as wide. They are more decidedly pear-shaped than any referred to the dorsal series. In each case there is a single facet for the attachment of the rib on a short straight process at the level of the ventral surface of the centrum. On No. 503.14 the diapophysis and parapophysis are united. The high combined articular face is markedly constricted at mid-length, but is continuous. Above and below the constricted portion the areas are essentially the same. Similar evidence of the combination is seen in the partial coalescence of the processes themselves. On No. 403.14 the union is essentially complete. The articular face is much higher than wide with no evidence of lateral constriction. Whether this condition represents an actual union of the diapophysis and parapophysis is a matter of speculation. One or the other process may have been completely suppressed in an intervening, lost series. On the most posterior representative, No. 503.15, the process is circular in cross-section and the articular face is of about the same diameter as the width of the much higher articular face of the preceding caudal representatives.

No. 503.14 (Plate XXXIII, fig. 2) is representative of the anterior caudals. It is 110 mm. high and 110 wide. The length is 38 mm. The posterior face slopes regularly from the margins to the center. The anterior face is very broadly rounded rather than flattened within the margins and the slope to the center is less abrupt than on the posterior face.

THE LIMBS

There is preserved a portion of one limb consisting of the propodial, epipodials with associated supernumerary, and two

bones from the third range. While the limb is very similar to that figured by Knight[5] as the right pectoral, the two limbs are clearly from opposite sides and the writer is reasonably certain that the present specimen is from the right side. The determination of Knight's specimen as the pectoral paddle is not questioned.

It seems likely that the specimen figure by Marsh as the left hind paddle of *Sauranoson* (*Baptanodon*),[6] an identification questioned by Gilmore[7] because of the three articular faces on the distal end, is a pectoral limb. The present specimen is almost identical with that figured by Marsh except that the two limbs are from opposite sides of the body. Both are different in certain details from the front limb of *Baptanodon*.

The *humerus* in the present specimen is a short, massive bone with the plane of the distal expansion at an angle of about 38° with that of the proximal articulation. The following table of measurements will show the more striking features.

	mm.
Length	176
Proximal width	120
Proximal thickness	80
Distal width	146
Distal thickness	63
Facet for *ulna*-length	65
Facet for *radius*-length	67
Facet for epipodial supernumerary	45

The proximal articulation is essentially quadrangular in outline. The irregularly pitted surface is broadly convex and rounds into the pronounced trochanter major. The latter is a broad, somewhat rugose ridge extending in the direction of the postero-distal margin and losing its identity somewhat below the mid-length of the bone. One of the distinguishing features, one in

[5] Knight, W. C., Notes on The Genus *Baptanodon* with a Description of New Species, Am. Jour. Sci., [4], 16, 76–81 (1903).

[6] O. C. Marsh, The Limbs of *Sauranodon*, with Notice of a New Species, Am. Jour. Sci., [3], 19, 169–171 (1880).

[7] Gilmore, C. W., Osteology of *Baptanodon*, Memoirs of the *Carnegie Museum*, 2, No. 2, 15 (1905).

which it resembles the limb figured by Marsh[8] as *Sauranodon discus*, is the pronounced rugosity on the inferior, pre-axial surface near the distal margin.

The *radius* is preserved entire. It is roughly quadrangular in shape, 57 mm. long and 67 mm. wide. The outer margin is considerably thinner than the inner. Except for a short space on the outer side there is no suggestion of a finished margin. The marginal surfaces are, rather, markedly and coarsely rugose. Apparenty the tibia and all other bones below the femur were firmly united in a single cartilagenous unit.

The *ulna* was apparently more nearly circular in outline. Only the posterior half is preserved. The length is approximately 40 mm. Its width may well have been as much as 50 mm.

A *supernumerary epipodial*, essentially circular, about 38 mm. in diameter, occupies the third, rather poorly set off articular facet of the femur. Parts of two more units in the third range of bones are preserved as indicated in the accompanying drawing, Plate XXXIV.

RELATIONSHIPS

While the fragmentary nature of the remains here described prohibits an authoritative discussion of the relationships, certain distinguishing features are evident. The several North American Triassic ichthyosaur genera among which one might well expect to find an ancestral form are all placed in the family Mixosauridae.[9] Among the striking features of this group that may be compared safely with the present form are the rib attachment and the epipodial development. The short, disk-like epipodials and the distinctly bicipital dorsal rib attachment of *Apatodonosaurus* contrast markedly with the more or less elongate epipodials and the unicipital ribs of the *Mixosauridae*.

While *Apatodonosaurus* should probably be placed with the *Icthyosauridae*, the wide post-orbital bar of the former seems sufficient to distinguish it from previously recognized genera of this family.

[8] Marsh, O. C., The Limbs of Sauranodon with Notice of a New Species. Amer. Jour. Sci (3), 19, 170 (1880).

[9] John C. Merriam, *loc. cit.*

THE TYPE OF APATODONOSAURUS

The material, the type of the new genus and species, *Apatodonosaurus grayi*, is recorded in The University of Missouri vertebrate paleontology collections as No. 503. The specific name is given in honor of the finder of the specimen, Mr. Shapleigh Gray, at the time a student of geology in the University of Missouri.

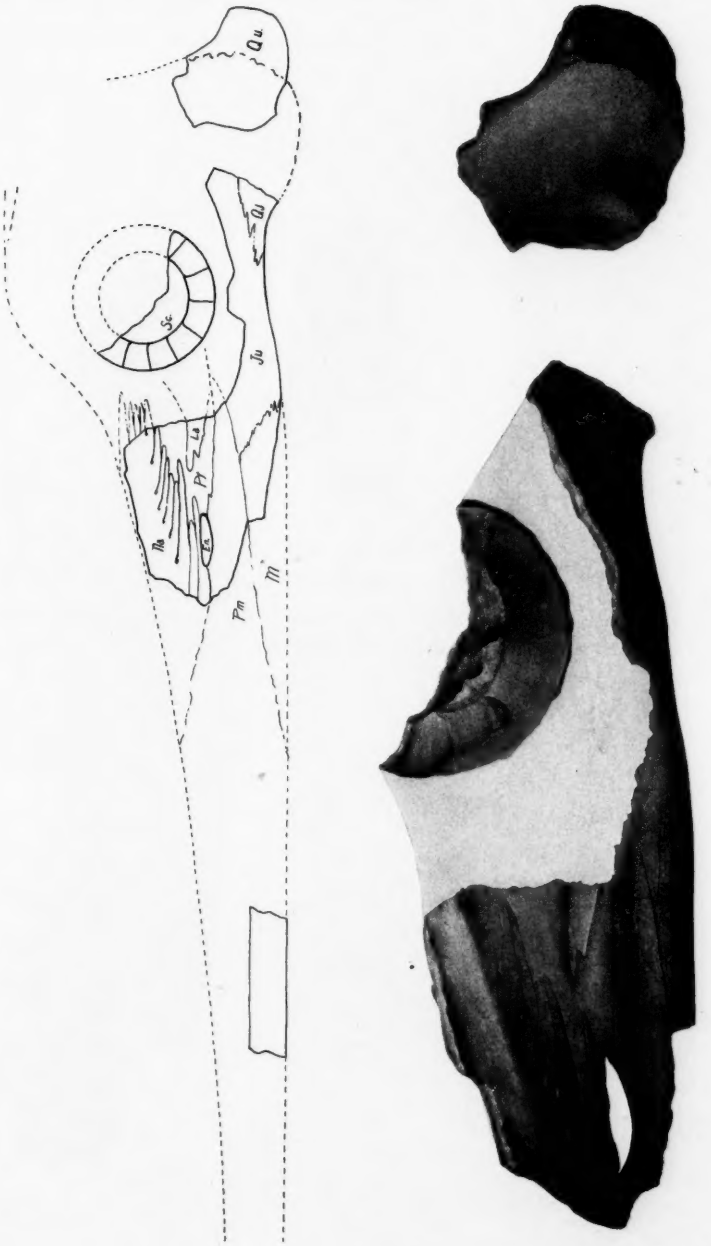
ABSTRACT

A new genus of ichthyosaurs from the Sundance of Wyoming is described. Some of the outstanding characteristics are: slit-like, anterior nares; small orbit with plates of schlerotic ring interlocking in a firm capsule; post-orbital bar wide; lower jaw edentulous; upper dentition almost functionless; ribs bicipital; epipodials of three units.

PLATE XXX

APATODONOSAURUS GRAYI

Lateral view of left side of skull fragments to show relative position of nares, orbit, and quadrate. The quadrate is the right, viewed from within. Shaded drawings are approximately one-third natural size. The outline guide drawing is one-sixth natural size.


Qu
Qu
Sc
Ju
Pr
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Ra
Ep
Pm
M

PLATE XXXI

APATODONOSAURUS GRAYI

Lower jaw; *A* and *B*, outer and inner view of posterior end of left ramus; *C*, superior view of coronoid region of the right ramus. All figures one-third natural size.

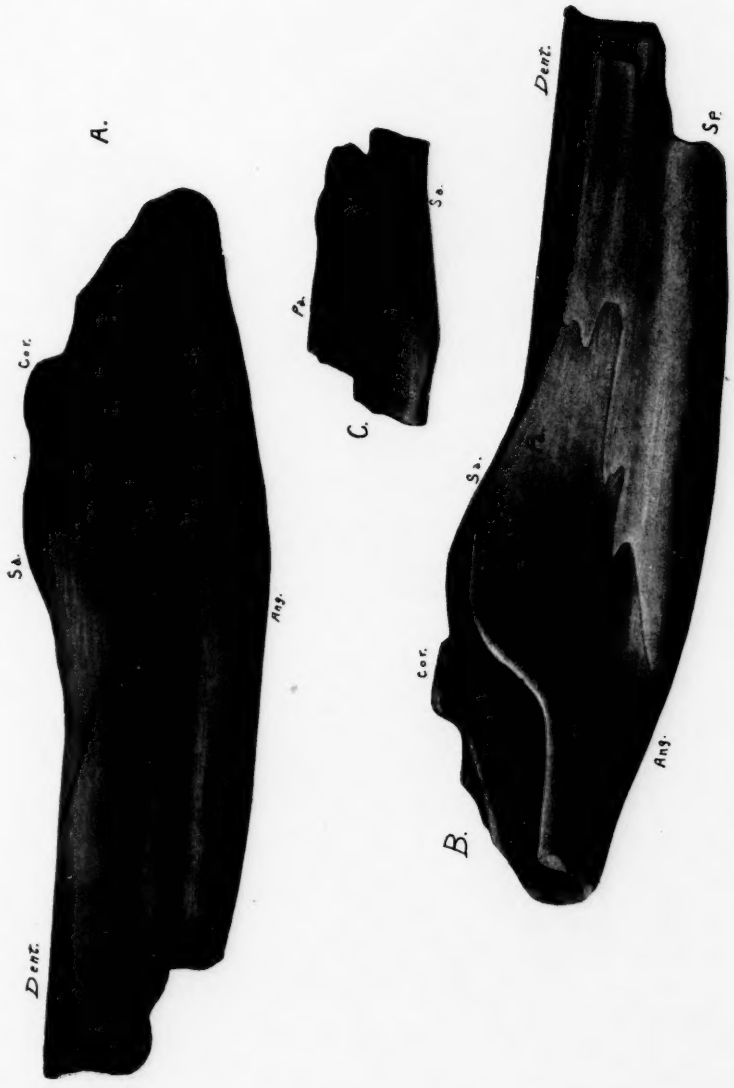

A.
Cor.
Sa.
Ang.
Dent.
C.
Pa.
So.
Dent.
Sp.
So.
Cor.
Ang.
B.

PLATE XXXII

Apatodonosaurus grayi

Details of dentition; *1*, outline drawing (lateral view) of premaxillary teeth; *2*, cross-section of mid-length of rostrum to show medianly directed teeth and deep lateral margin of alveolar groove; *3*, base of a maxillary tooth about two times natural size; *4*, side view of another maxillary tooth, about three and one-half times natural size.

3.

4.

1.

2.

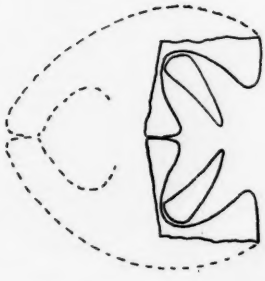


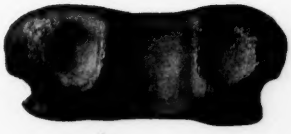
PLATE XXXIII

APATODONOSAURUS GRAYI

Vertebrae from cervical and anterior dorsal regions: *1a*, *1b*, and *1c*, posterior, left-lateral, and superior views of typical cervical (No. 503.7); *2a* and *2b*, left lateral and posterior view of anterior dorsal (No. 503.7). Figures one-half natural size.

1a.

1b.



1c.

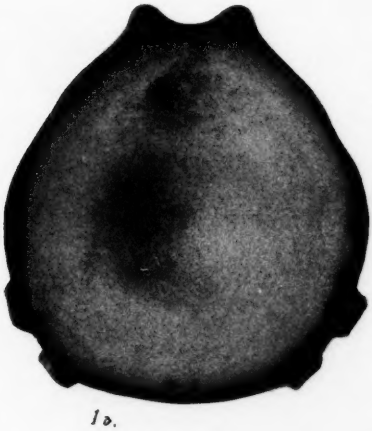
2a.

2b.

PLATE XXXIV

APATODONOSAURUS GRAYI

Dorsal and caudal vertebrae and rib: *1a* and *1b*, anterior and right lateral view of posterior dorsal vertebra; *2a* and *2b*, right lateral and anterior view of anterior caudal vertebra; *3*, rib from cervical region; all figures one-half natural size.

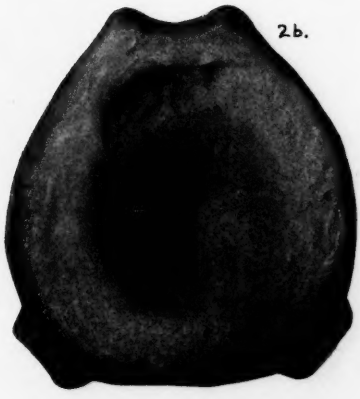


1a.

1b.

3

2a.



2b.

PLATE XXXV

APATODONOSAURUS GRAYI

Right pectoral paddle seen from lower posterior side; one-half natural size.

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